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Final QAPP
12686

Remedial Investigation - Feasibility Study
City of Sturgis Well Field
Sturgis, Michigan

Prepared for:

Michigan Department of Natural Resources
Lansing, Michigan

Prepared by:

Warzyn Engineering Inc.
Madison, Wisconsin

August 1987

MASTER

WARZYN

Remedial Investigation - Feasibility Study City of Sturgis Well Field Sturgis, Michigan

August 1987

QUALITY ASSURANCE PROJECT PLAN (QAPP) FOR
STURGIS MUNICIPAL WELL FIELD
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

SEP 21 1987

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Prepared By:

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Francine Allans EPA Remedial Project Manager	9/4/87
*** Thomas H. Adams, Jr. EPA Region V Quality Assurance Officer	8/26/87

*** This approval is for all activities except the field analysis of volatile organics.

WARZYN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

DATE: September 15, 1987

SUBJECT: Approval of Field Screening Procedure of Volatile Organics to be used at the Sturgis Muncipal Well Field Site, Michigan

FROM: James H. Adams, Jr., Chief
Quality Assurance Office

TO: Thomas Geishecker, Chief
Program Support Section

ATTENTION: Lois Betka

This memorandum transmits our Office's approval of the procedure for field screening of volatile organics at the Sturgis Municipal Well Field Site, Michigan. This approval is provided after our Office has modified the revised procedure, which was submitted to our Office on September 8, 1987. It is our understanding that data generated from the field screening will be used for selection of sampling location only and will not be used for other purposes.

With the approval of the procedure for field screening of volatile organics, the Quality Assurance Project Plan (QAPP) is now approved for all activities specified in the QAPP for this project. Please have the remedial project manager provide final sign off. We have retained a copy of this procedure for our records; however, we would like to receive a copy of the complete signature page when it is available.

cc: K. Chiu, ERRB
F. Allens, PSS

1.0 INTRODUCTION

The United States Environmental Protection Agency (USEPA) requires participation of all USEPA contractors in a centrally managed Quality Assurance (QA) program. This requirement applies to all environmental monitoring and measurement efforts mandated or supported by USEPA.

Each contractor generating data has the responsibility to implement minimum procedures to assure that the precision, accuracy, completeness and representativeness of its data are known and documented. To insure the responsibility is met uniformly, each USEPA contractor must prepare a written QA Project Plan (QAPP) covering each project it is contracted to perform.

This QAPP presents the organization, objectives, functional activities and specific QA and Quality Control (QC) activities associated with the Remedial Investigation/Feasibility Study (RI/FS) at the Sturgis Municipal Well Field site in Sturgis, Michigan. The QAPP is designed to achieve the specific data quality goals of the RI/FS.

This QAPP has been prepared in accordance with the requirements of the Quality Assurance Program Plan and the following guideline documents:

- USEPA, December 1980, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80
- USEPA, Region V, December 1985, Preparation of Federal Lead Remedial Investigation Quality Assurance Project Plans for Region V
- USEPA, Region V, April 1984, Preparation of State-Lead Remedial Investigation Quality Assurance Program Plans for Region V, Draft

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Position	Name
Project Manager - Warzyn	Ken Quinn
Project Hydrogeologist - Warzyn	Tim Melka
Environmental Chemist - Warzyn	Steve Wiskes
Sample Coordinator - Warzyn	Brian Hegge
Project Manager - Michigan DNR	Steven Luzkow
Quality Assurance Officer - Michigan DNR	George Jackson
Project Geologist - Michigan DNR	Kathy Shirey
Remedial Project Manager - EPA	Francine Allans

3.0 Project Description

The remedial investigation portion of the RI/FS is designed to gather specific information necessary to determine if the site presents a hazard to human health or welfare or to the environment and to collect data to evaluate potentially feasible remedial alternatives. All tasks and subtasks are directed toward accomplishment of the primary objectives. The Sturgis Municipal Well Field RI/FS is a Michigan Department of Natural Resources (MDNR) lead project.

3.1 Background

The City of Sturgis is located approximately two miles north of the Michigan and Indiana border in St. Joseph County. The city lies within Fawn River, Sturgis, Burr Oak and Sherman Townships. The areas to be investigated are located in Section 36 of Sherman Township, (T7S and R9E), Section 1 of Sturgis Township (T8S and R9E), and Section 2 of Sturgis Township (T8S and R9E). (See Figure 1 for the general location of the City of Sturgis.)

The City of Sturgis provides water to nearly 10,000 city residents. In addition, the City provides water to most businesses, industries and service institutions within the City. In 1982, the water supply wells consisted of the 4 wells (Jackson PW-1, Layne PW-2, Kirsch PW-3 and Lakeview wells PW-5) shown on Figure 1. During routine chemical testing of the municipal water supply in 1982, the Michigan Department of Pubic Health (MDPH) found that the water from two City wells, Wells PW-1 and PW-2, were contaminated by two volatile organic compounds (VOCs), trichloroethene (TCE) and tetrachloroethene (PCE). The concentration of TCE increased substantially in the Well PW-1 during the first year after it was identified (from 26 ug/L to 152 ug/L). (See Table 1).

In August and September 1982, the State of Michigan Department of Public Health (MDPH) recommended that the City investigate the source of the VOCs, discontinue use of the two contaminated wells, and begin searching for a new well site. In October 1982, the City hired Gove Associates to investigate the TCE contamination in Sturgis in an effort to locate its source. Also, in

October 1982, PCE was first detected in Well PW-1. In May 1983, Gove Associates issued their report concluding that they were unable to locate the source of TCE contamination through a limited groundwater investigation. Also during May, the City began to increase the pumping rate of two other wells, Well PW-4 (located in the southeast portion of the City, see Figure 1) and Well PW-3 (the western well shown on Figure 1).

In July 1983, the City asked the residents to voluntarily limit their drinking water consumption. In November 1983, TCE was discovered at an industrial water supply well (Well No. R4 on Figures 1 and 2) located approximately 2,000 ft northwest of the two contaminated city wells PW-1 and PW-2. In April 1984, the City began using water from a new well, Well PW-5, located on the south side of the City. Pumpage was discontinued at the wells PW-1 and PW-2, and was increased in Wells PW-3, PW-4 and PW-5. In January 1985, TCE was detected at Well PW-3 located approximately 2,700 ft west of Wells PW-1 and PW-2. Since January 1985, Well PW-1 has been abandoned, Well PW-2 has not been used, and Well PW-3 pumpage has been significantly decreased. The City at present relies primarily on two wells located on the south and southeast sides of the City (Wells PW-4 and PW-5, respectively) to supply the majority of its municipal water requirements. However, during peak periods Well PW-3 is used to provide up to 25 percent of the municipal water supply. Limited mixing of water from Well PW-3 is reported to occur with the other city water when this well is used.

Geology

Sturgis is located in an area of extensive glacial outwash approximately 1/2 mile to the south of a recessional moraine belonging to the Sturgis-Kalamazoo Morainal System. According to logs from well locations and test borings, two thick sand and gravel units, that are separated by a clay layer lie below the City. The lower sand and gravel unit is the aquifer utilized by the municipal and industrial water supply wells and is 80 to 120 ft thick. It is present from approximately 60 ft to 190 ft below ground surface, the base of this aquifer is formed by a thick lacustrine clay.

The clay layer separating the two sand and gravel units is found at a depth of 50 to 60 ft and varies in thickness from 15 to 40 ft. This clay layer appears to be continuous throughout the northern and western portion of the City based on information obtained from individual well logs. The upper sand unit varies from 50 to 60 ft in thickness.

In this area of the state, 200 to 400 ft of glacial material lies above the Marshall Sandstone of the Osagean Series, and the Coldwater Shale of the Kinderhookian Series, which are both Mississippian in age (Western Michigan University, 1981).

Topography and Hydrology

Maximum topographic relief in the City is about 40 ft with topographic slope trending from northeast to south and southwest toward the Fawn River (see Figure 1). A chain of lakes is located to the north and northwest of the City. The lakes are the source of the Prairie River which flows to the northeast. To the south of the City, the Fawn River flows to the southwest and west. A surface water divide, located to the north and east of the City, follows the margin of the end moraine. Two intermittent surface streams are located to the southwest of the City and flow to the southwest. The Nye Drain, located south of the City, flows to the west.

Hydrogeology

The Sturgis municipal wells utilize a two aquifer system which consists of two sand and gravel deposits separated by a till deposit, which acts as a confining layer. Municipal wells pump water from the lower aquifer. A limited number of monitoring wells installed in the study area are screened in both the upper and lower sand and gravel units. Static water levels for monitoring wells installed in the lower aquifer are slightly lower than in wells installed in the upper aquifer, suggesting a small downward gradient, although no well nests have been installed. In addition to groundwater recharge from infiltrating precipitation, industrial effluent discharge contributes to groundwater recharge in relatively small areas in the northeastern portion of the City.

Regionally, in the absence of pumping influence, groundwater is assumed to flow from the northeast to the west and southwest in the vicinity of the City of Sturgis. This assumption is based on the location and flow direction of the Fawn river and general topographic slope. Published studies of the area are unavailable. Gove and Associates, Inc. of Kalamazoo (1982), in a groundwater study conducted in Sturgis, reported that groundwater flow is toward the west and southwest. However, their statement on groundwater flow direction is based on similar surface observations.

During the past three years pumpage from the lower aquifer to the municipal water supply system varied from 2.2 to 2.6 million gallons per day (mgd), based on a monthly average. The location of the majority of pumpage has recently been shifted from Well PW-3, due to the TCE contamination observed in this well. Although Well PW-3 is still in operation, its use has been reduced significantly over the three year period. Well PW-1 was abandoned, and Well PW-2 had been removed from service and abandoned (based on discussion with the City Engineer). Current water supply operations use Wells PW-4 and PW-5 to provide the majority of the city's water supply. Well PW-3 is used only during peak periods. Undoubtedly, local variations in groundwater flow occur as a result of municipal pumpage. In addition, industrial wells also use groundwater from the lower aquifer which causes further variations in local groundwater flow. The historical pumping rates for the industrial users are unknown at the present time.

Socioeconomic

Approximately 10,000 people reside in the City of Sturgis and nearly all are supplied with municipal water. Businesses and industries located in the vicinity of the contaminated wells include dry cleaners, metal fabricators, plastics manufacturers, paper producers, printing establishments, other factories and a foundry, as reported by TechLaw (1984). Some of the factories and the foundry have been granted a license by MDNR to dispose of non-contact manufacturing effluent in gravel pits adjacent to their locations.

The City has, in the past, hired various consultants in an attempt to locate the source of the contamination and to locate alternate potable water supplies. The City has modified pumping schedules to avoid or eliminate the use of contaminated wells. City officials recognize that continued use of Well PW-3 may produce water quality in excess of proposed drinking water standards and that this presents a potential threat to public health. Little or no public concern has been expressed.

Previous Remedial Actions

To date, remedial actions include a study by Gove Associates who were unable to identify the source of contamination. The MDPH water sampling program, which initially identified the problem, has been continued through analysis of several samples between 1982 and 1986 (See Table 1). In order to replace the loss of production after removing Wells PW-1 and PW-2 from the system, the City installed Well PW-5. The city is also contemplating installation of another well to replace Well PW-3.

An industry in the northern portion of the City had 3 of their 4 wells (Wells R1, R2 and R4 shown on Figure 2) affected by TCE and PCE. This problem area has been referred to as the W. Lafayette St. Area in the MDNR's records. The industry responded by installing a new well north of the plant. Although the new well is clean, the industry is using carbon adsorption treatment for that water which is used for consumption and as ingredient water in their manufacturing process (based on discussion with the plant engineer).

Assessment of Existing Information

Water samples have been collected from the production wells since 1955 by the MDPH on an irregular basis. TCE was first detected in samples from Wells PW-1 and PW-2 in June 1982. Since then, the production wells remaining in use have been sampled at least on a yearly basis for volatile organic compounds (VOCs) and indicator parameters.

A rapid increase in TCE and PCE concentrations was noted in Wells PW-1 and PW-2 between 1982 and 1983. Between June 1982 and May 1983, TCE concentrations in Well PW-1 continuously increased (with the exception of the 8-20-82 sample) from 26 ug/L to 152 ug/L, while TCE at Well PW-2 fluctuated between 2 ug/L and 43 ug/L during the same period. PCE was detected only at Well PW-1 and increased in concentration 1 ug/L to 3 ug/L between September 1982 and May 1983. Pumping at these wells was subsequently stopped.

No VOCs were detected at Well PW-3 between May and December 1983. During this period the pumping of Well PW-3 was increased to replace the Wells PW-1 and PW-2 so that it provided approximately 50% of the water supply by 1984. In January 1985, TCE was identified at the Well PW-3, 8 months after discontinuing use of Wells PW-1 and PW-2. The concentration has fluctuated between 1 ug/L and 6 ug/L at Well PW-3 between January 1985 and May 1986. The concentrations of inorganic chemical constituents in individual municipal wells have remained relatively unchanged through time. However, the chemistry of the wells in the central part of the city (Wells PW-1, PW-2 and PW-3) differ somewhat from those in the southern part of the City (Wells PW-4 and PW-5). Chloride (13 to 20 mg/L), nitrate (3.1 to 5.6 mg/L), sulfate (38 to 51 mg/L) and hardness (315 to 319 mg/L) concentrations are higher in the central wells than they are in the southern wells (Chloride:4 to 8 mg/L; Nitrate:0 to 1 mg/L; Sulfate:22 to 32 mg/L; hardness 278 to 309 mg/L). Other inorganic parameters (pH, conductivity, alkalinity, calcium, magnesium, sodium and potassium) are similar at all locations.

In addition to TCE and PCE, MDPH has identified bromoform and other trihalomethanes in the water supply. It is assumed that these compounds are the result of in-line treatment of the drinking water supply and are not groundwater contaminants. However, these compounds will be included in the RI analysis. No other priority pollutants have been detected to date.

3.2 Project Objectives

The primary objectives of this RI/FS are as follows:

- Determine the extent of contamination to the aquifer which supplies the city of Sturgis municipal water supply;
- Identify, if possible within the limits of this RI, the source(s) of the volatile organic compounds (VOCs) contamination of the aquifer and characterize the source(s) identified;
- Evaluate the threat posed by the contamination to the public health and welfare;
- Develop and select a remedial response(s) to reduce or eliminate the potential threat to public health.
- Identify alternate well field locations for municipal water supply that may not be affected by the identified VOCs contamination.

3.3 Objectives of Specific Project Elements

The RI/FS includes seventeen general tasks, each having several subtasks. the tasks have been outlined as follows:

Task 1 - Previous Investigations and Remedial Actions
Task 2 - Plans and Management
Task 3 - Preliminary Evaluation of Potential Sources
Task 4 - Phase I Site Investigation
Task 5 - Phase II Investigation
Task 6 - Community Relations
Task 7 - Remedial Investigation Report
Task 8 - RI Project Management
Task 9 - Work Plan Revision
Task 10 - Exposure Assessment
Task 11 - Preliminary Remedial Technologies
Task 12 - Development of Alternatives
Task 13 - Initial Screening of Alternatives
Task 14 - Detailed analysis of the Alternatives
Task 15 - Evaluation of Cost-Effective Alternatives
Task 16 - Preliminary Report
Task 17 - Final FS Report

The environmental monitoring and measurement effort covered by this QAPP are limited to subtasks within Task 3, Preliminary Evaluation of Potential Sources, Task 4, Phase I Site Investigations and Task 5, Phase II

Investigation. Tasks 3, 4 and 5 will be performed to gather data which is needed to accomplish the RI/FS objectives.

The RI will contain the following subtasks that are designed to collect representative data reflecting conditions on and around the site.

- Industrial Site Survey
- Preliminary Model Development
- Site Investigation Preparation
- Water Quality Sampling of Existing Wells
- Soil Gas Survey
- Well Drilling
- Surface Water and Sediment Sampling Investigation
- Groundwater Sampling and Aquifer Testing
- Groundwater Level Monitoring
- Topographic Survey

The specific RI objectives are as follows:

TASK 3 Preliminary Evaluation of Potential Sources

Subtask 3.1 Industrial Site Survey

There are numerous potential source areas of TCE and PCE within the City of Sturgis identified in the TechLaw Report (1984). Based on the presumed groundwater flow direction and the observed contaminant distribution, the likely area for potential source areas has been identified as an area approximately north of Chicago road (US Highway 12). Prior to initiating the site investigation at the relatively large plants, a plant survey will be conducted with the cooperation of each industry. The intent of the surveys is to view the operations of the plants and determine where solvents have been stored, used or disposed on the plant grounds, both under the current operations and in the past. Surveys are currently planned for the Sturgis Foundry, the Kirsch Company, the Frye Printing Company, United Paper and the Bandholtz Paint Manufacturing Company.

Additional discussion of Subtask 3.1 can be found in the Work Plan.

Subtask 3.2 Preliminary Model Development

A preliminary estimate of groundwater flow directions through groundwater flow modeling will be developed to identify areas which may contain possible sources. The objectives of the preliminary modeling are:

- To identify possible groundwater flow directions under variable pumping rates
- To outline plausible contaminant source areas within the zones of capture of the Wells PW-1 and PW-2 and Well PW-3 prior to and during the time each well was contaminated
- To determine whether the same source could account for the contamination at Wells PW-1, PW-2, PW-3 and the northwest industry wells
- To identify the aquifer parameters to which the simulated groundwater flow direction and velocity are most sensitive. Knowledge of these sensitivities will allow the investigation to focus on those areas or parameters that will control potential remedial actions and the potential changes in contamination distribution under various alternative pumping scenarios.

Additional discussion of Subtask 3.2 can be found in the Work Plan.

TASK 4 Site Investigation

Subtask 4.1 Site Investigation Preparation

In preparation for the on-site gas chromatography (GC) analysis of soil gas and water quality samples using an on-site GC, a short method development and calibration study will be conducted with the GC in the lab. The study will establish the most efficient and effective methods (i.e. detection limits, temperature program, column type and standards preparation) to detect TCE and PCE. The data from the soil gas and water samples analyzed by on-site GC will be used only as a guide for well locations and screen placement. All concentration data will be considered estimated and compound identifications as tentatively identified (See Appendix G for methodology).

Subtask 4.2 Water Quality Sampling of Existing Wells

Thirty-one (31) monitoring and water supply wells be sampled for water quality. The purpose for this sampling and analysis is to provide information on existing site conditions at the beginning of the study. These data are intended to be used in characterizing the nature and extent of contaminants and evaluating potential remedial actions.

VOC samples will be analyzed using CLP SAS by GC/MS to provide information on the existing water quality conditions on the site. The requested SAS will provide lower detection limits than those available using routine CLP protocols. Lower detection limits are required for this study to adequately define the extent of groundwater contamination and potential risks associated with its consumption. See Appendix D for the CLP SAS methodology for VOCs.

In addition, samples will be analyzed by CLP SAS for the following water quality parameters: (See Appendix D for methodology).

Sodium (dissolved)*
Potassium (dissolved)*
Calcium (dissolved)*
Magnesium (dissolved)*
Alkalinity
Sulfate
Chloride
Nitrate Nitrite-N
TKN
TOC

* filtered through 0.45 micron filter paper prior to preservation.

TOC will be used as a non-specific indicator of organic carbon concentration. It will be used in conjunction with results of VOCs analyses to indicate the extent to which organic compounds have been identified and as an indicator of total carbon that may require treatment. Because low levels are anticipated, lowest available detection limits are requested. The other parameters listed above, constitute major expected dissolved groundwater components. These will to establish spatial differences in groundwater characteristics and as an aid in defining flow patterns and the degree of interaction between aquifers. TKN is used with nitrate-nitrite data as a nonspecific indicator of other than nitrate-nitrite nitrogen. These forms may include ammonia and organically combined nitrogen. These data will be used as an indicator of redox status of the system and as an indicator of total potentially available nitrogen supplies in the groundwater system.

Field measurements for pH, specific conductance and temperature will also be made on these samples. Specific conductance will be used with indicator parameters to check completeness with which ionized species have been identified. PH will be used to aid interpretation of groundwater chemistry including speciation and potential solid phases that may be controling solubility of dissolved species. See Appendices C1 and C3 for methods. Additional discussion of Subtask 4.2 can be found in the Work Plan.

<u>Subtask 4.3 Soil Gas Survey</u>

Soil gas sampling will be conducted in order to help identify potential source areas and in an attempt to map the distribution of the plume that may be present at the water table surface in the immediate area of a potential source. Results of on-site GC analyses of the soil gas samples will be used only to guide the selection of well locations. Soil gas sampling will consist of driving a probe to a depth of approximately 3 ft, purging the sampling probe and tubes and collecting a sample in a glass gas vial. The sample will be returned to the on-site GC for analysis. Soil gas sampling will be conducted at 14 locations where TCE and/or PCE is believed to be (or have been) used. Figure 3 shows the locations of the soil gas sampling. Table 2 is a list of the sites planned to be surveyed. A total of 82 soil gas samples will be collected for the purpose of evaluation of potential sources. If contaminated sources are located, additional soil gas samples may be collected to aid well locations. The samples will be analyzed for VOCs. See Appendix G for methodology. All field locations will be documented in the field sampler's logbook. All analytical results will be documented in the GC operator's logbook.

Subtask 4.4 Well Drilling

Eleven monitoring wells at seven locations are planned based on the vertical and horizontal placement of the pumping wells and the locations of potential contaminant sources identified through present and past industrial practices in the area. Locations for these wells are shown on Figure 2. The rationale for these locations is presented in Table 3. Seven other wells will be located based on the results of the soil gas survey and on-site groundwater quality sampling and analysis. Therefore, only 11 of the 18 planned wells have specific locations for this QAPP.

Split spoon sampling will be done at the deepest well in each nest on a 5-ft interval to a depth of 25 ft and a 10-ft interval to the bottom of the hole or at changes in soil type. All samples will be logged by the geologist or geotechnical engineer present at the drilling rig. Each of the deep wells will be logged using a natural gamma ray logging tool, a Mount Sopris 1000C unit. The gamma ray log will provide information on the clay content of the formations penetrated and will be used in selecting the vertical position of the well screen (See Appendix F.)

Eighty-one water quality samples will be collected during drilling of wells listed in Table 3. Sampling locations through both upper and lower aquifers will be selected to help identify the plume distribution prior to setting the well screen. These samples will be analyzed using an on-site GC (See Appendix G for methods). The data will be used to help position the well screen of the well being drilled and locate additional wells. All data will be considered estimated and tentatively identified. An on-site GC is used for this screening analysis because of: 1) the low concentrations expected in portions of the aquifer, 2) the low reliability of field instruments in uncontrolled field conditions, 3) the large depth and cost of drilling up to 150 feet) requires the need for reliable, low detection analyses prior to setting the well screen. Thirty-eight (38) of the above mentioned samples will be submitted for laboratory GC/MS analysis by CLP SAS (See Appendix D for methods). These samples are to be analyzed using methods consistent with the analyses of groundwater samples collected in Subtask 4.6 and will serve to confirm results of field GC analysis. The method requested is designed to provide lower detection limits than CLP RAS protocols.

Subtask 4.5 Surface Water and Sediment Investigation

Eight surface water and eight sediment samples will be collected from a total of four gravel pits, disposal pits and non-contact effluent discharge points in the potential source area(s) to determine if TCE and/or PCE have been released. A surface sediment sample will be collected at each surface water sample location. The distribution of samples between the four locations will be based on results of the industrial site surveys and will be approved by the MDNR project manager.

All surface water samples will be analyzed for volatile organic compounds by CLP SAS. See Appendix D for methodology. Surface waters will be unfiltered. The intended data use for VOCs results for this project require the detection limit (DL) for TCE to be considerably less than the enforcement standard (Safe Drinking Water Act MCL of 5 ug/L). To obtain lower DLs the SAS provided in Appendix D uses a 25 ml purge volume. In addition, ~~surface water~~ samples will be analyzed for pH, specific conductance and temperature in the field (See Appendices C1 to C3). Sediment samples will be analyzed for VOCs CLP RAS.

All the surface water and sediment data are intended to be used in characterizing the nature and extent of contaminants and evaluation of potential remedial actions.

Subtask 4.6 Groundwater Sampling and Aquifer Testing

In addition to the sampling performed in Subtasks 4.2, 4.3, and 4.4; 18 monitoring wells (installed during Subtask 4.4), 17 pre-existing monitoring wells, 3 test wells, and 11 production wells will be sampled. Table 4 provides a summary of sampling and analysis. These samples will form the basis for RI analysis including source identification, nature and extent of contamination, determination of the mass of contaminants present and the evaluation of potential remedial action alternatives in the FS.

Groundwater samples will be analyzed for the following water quality parameters by CLP SAS (see Appendix D for methods descriptions).

VOCs
Sodium (dissolved)*
Potassium (dissolved)*
Calcium (dissolved)*
Magnesium (dissolved)*
Alkalinity
Sulfate
Chloride
Nitrate-Nitrite-N
TKN
TOC

* filtered through 0.45 micron filter paper, prior to preservation.

Intended use of data is the same as that described for the initial sampling round (Subtask 4.2). Field measurements for pH, specific conductance and temperature will also be made on these samples (See Appendices C1 and C3).

In addition to the above parameters, 10 samples will be selected for analysis of the HSL semi-volatiles, pesticides, PCBs, metals and cyanide by the CLP RAS (See compound list in Tables A-1 and A-2). The samples selected for analysis will represent water quality in potential source areas, downgradient of potential sources, and upgradient of potential sources. These locations will be selected based on results of the field analyses (soil gas and water quality sampling during drilling) and observations during drilling.

The intended data use for volatile results for this project requires the detection limit (DL) for TCE to be considerably less than the enforcement standard (Safe Drinking Water Act MCL of 5 ug/L). To obtain lower DLs, the SAS provided in Appendix D uses a 25 ml purge volume.

Hydraulic conductivity tests will be conducted on 20 wells. The wells to be tested will be determined during and after the drilling program. The tests will be performed in water table wells by removing a slug of water from the well and measuring recovery through the use of a pressure transducer and data logger. The data collected will be used to calculate the hydraulic conductivity of the aquifer (See Appendix E).

Subtask 4.7 Groundwater Level Monitoring

At the completion of the well installation program, water levels will be measured at all on-site wells. Water levels will be measured concurrent with each groundwater sampling effort. Four additional rounds of water levels will be collected during the course of the RI to record fluctuations in water levels. Groundwater levels will be measured to determine vertical and horizontal groundwater hydraulic gradients at the site. A water level measurement will be taken using a fiberglass tape measure fitted with a sounding device.

Subtask 4.8 - Location and Elevation Survey

A location and elevation survey of all monitoring and production wells will be performed by Kumar Malhotra and Associates, Inc. (KMA) during the site investigation. Elevations will be obtained for the top of well casings to ±0.01 ft, and the ground surface to ±0.1 ft at all borings. The location and elevation survey will note other pertinent site features which may affect groundwater flow or contaminant distribution, such as surface water bodies and specific contaminant source areas.

3.4 Project Schedule

A project schedule from the Work Plan is presented in Table 5. The final RI report is scheduled to be completed within 58 weeks after initiation of field work (dependent on CLP testing time and scope of Phase II) and the FS within an additional 11 weeks. Project quality assurance audits are scheduled during both the RI and FS phases.

3.5 Intended Use of Data

Previous investigations at Sturgis Municipal Well Field have indicated contamination of groundwater. The extent of contamination is, however, not currently known. The data collected will be used to identify sources of VOC contamination of the aquifer, characterize the extent of environmental contamination and assess the importance of any current or potential contaminant releases on public health, welfare and/or the environment. The only known route of contaminant migration in the area is via groundwater.

This route as well as direct and indirect contact with soil, sediment and surface water will be investigated.

In addition to data collected to characterize contaminant extent, supporting data needed to evaluate potential containment and treatment alternatives will be obtained. These data include physical properties of subsoil and the local aquifer.

Some data collected using direct reading, portable instruments will be used primarily for health and safety purposes. Soil gas and groundwater data obtained from the on-site GC will be used only to guide the selection of well locations. Results from the on-site GC are intended to be used for screening purposes only.

3.6 Sampling Summary

Table 4 provides a summary of all anticipated sampling that will occur in conjunction with the RI/FS at Sturgis Municipal Well Field. The table is compiled by subtasks, matrix type and phase of study in which samples are collected. The table lists parameters, the number of samples to be collected, the lab analyzing the samples and the number of QC samples.

4.0 Project Organization and Responsibility

4.1 Overall Responsibility

- Steven Luzkow - Project Administrator, MDNR
- Francine Allans - Remedial Project Manager, USEPA Region V
- Kenneth J. Quinn, Project Manager, Warzyn Engineering Inc.
- Dan Hall, Project Administrator, Warzyn Engineering Inc.
- RI/FS Reports and technical memoranda prepared by Warzyn Engineering Inc.

4.2 Monitoring and Sampling Operations and QC

- Principal Engineering Firm - Warzyn Engineering
- Drilling - Exploration Technology, Inc.
- Sampling and Monitoring - Supervised by Warzyn Engineering Inc. with assistance from C.C. Johnson/Malhotra and Engineers International

- Surveying - Organized by C.C. Johnson/Malhotra with QC by Warzyn Engineering Inc.,
- Quality Control - Richard Maurer Warzyn Engineering Inc. (Quality Assurance Officer) or his designate.

4.3 Laboratory Analysis and QC

- Contract Laboratory Program (RAS and SAS) Contact-CPMS, CRL, Region V
  - VOCs (SAS and RAS)
  - Alkalinity, chloride, sulfate, nitrate-nitrite, TKN, TOC, calcium, magnesium, sodium and potassium
- Field analysis of pH, specific conductivity and on-site GC screening - Warzyn Engineering - Michael Linskens, Lab Director

4.4 Specialized Responsibilities for Laboratory Services

Contract Laboratory Program (CLP)

- CLP Routine Analytical Services (RAS)
  - Request initiated by Warzyn
  - Support Services Branch, Office of Emergency and Remedial Response, U.S. EPA headquarters - overall management of CLP
  - U.S. EPA EMSL, Las Vegas - Quality Assurance oversight of CLP laboratories
  - Final data review of U.S. EPA Region V Contract Project Management Section, CRL
  - Review of tentatively identified compounds and assessment of need for confirmation by Warzyn

- CLP Special Analytical Services (SAS)
  - Requests initiated by Warzyn
  - Requests coordinated though U.S. EPA Region V Environmental Services Division or U.S. EPA Region V Remedial Response Branch or U.S. EPA RPM
  - Review of SAS specification U.S. EPA Region V QA office and CRL
  - Final data review by U.S. EPA Region V CPMS, CRL.

4.5 Quality Assurance

- Overall QA Responsibility-Warzyn Quality Assurance Officer (QAO)
- Warzyn and Warzyn subcontracted activities-MDNR, U.S. EPA Region V
- CLP RAS
  (1) Support Services branch, OERR, EPA headquarters
  (2) EML Las Vegas, EPA
  (3) CPMS, CRL
  (4) EPA Region V QAO

- CLP (SAS)
  (1) CPMS, CRL
  (2) Region V, QAO
  (3) Warzyn
- Field Analysis-Warzyn

4.6 Performance and Systems Audits

- Field operations - QA officer, Warzyn Engineering
- CLP-Support Services Branch, OERR, EPA and EMSL-Las Vegas EPA
- Evidence Audit - MDNR and NEIC, U.S. EPA

A project organization chart is shown on Figure 6.

5.0 Quality Assurance Objectives

The majority of samples collected during this study will be used to characterize the nature and extent of contamination at the site. The overall QA objective of these samples is to develop and implement procedures of field sampling, chain-of-custody, laboratory analysis and quality control (QC) reporting that will provide legally defensible results of documentable quality. These data will be used to identify the nature and extent of contamination in the aquifer, including the source area(s), evaluate potential remedial actions and evaluate potential risks to human health and the environment. Specific procedures to be used for sampling, chain-of-custody, calibration, laboratory analysis, reporting, internal quality control, audits, preventative maintenance and corrective actions are described in other sections of this QAPP. This section defines the goals for the QC effort (accuracy, precision, and sensitivity of analyses and completeness, representativeness and comparability of measurement data) for these measurements.

In addition to samples collected to characterize the nature and extent of site contamination, VOCs data will be collected using a field GC to aid in sampling location selection for site characterization work. Data will be reported, but any compounds detected will be considered tentatively identified and concentrations estimated. Sample documentation will be limited to the information contained in entries to field and laboratory notebooks and sample container labels.

5.1 Level of Quality Control Effort

5.1.a Field Sampling Program

The quality of data from the field sampling program will be evaluated through the collection of field duplicates, matrix spike/matrix spike duplicates and field and trip blanks. Duplicate samples will be used to assess the combined effects of sample collection, handling and analysis on data precision. Blank samples will be used to check for procedural contamination or ambient conditions at the site that may cause contamination. The general level of effort for all matrices will be one field duplicate per 10 investigative samples, one field blank per 10 investigative samples. However, field blanks will be collected at a frequency of one per collection method per sampling time. For organics analysis of water samples, additional sample volume will be collected for matrix spike/matrix spike duplicate analyses at a frequency of one per 20 investigative samples. One trip blank will be included with each batch of water samples for volatile analysis.

Accuracy and reproducibility standards for survey activities will be consistent with those given in the standard survey reference, Classification Standards of Accuracy and General Specifications of Geodetic Control Surveys. All horizontal locations will be obtained to an accuracy of ±0.1 foot. Vertical elevations will have an accuracy of ±0.1 foot for the ground surface and ±0.01 foot for well casings.

5.1.b Laboratory Analysis

Surface water, sediment and the majority of groundwater samples collected will be analyzed using the USEPA Contract Laboratory Program (CLP). The level of laboratory QC effort for CLP Special Analytical Services (SAS) Analyses is described in the individual SAS Requests, attached in Appendix D. The QC goals of CLP RAS are established under guidelines stated in Invitation for Bid (IFB) documents WA-85-J664/J680 for organics and WA-85-J838/J839 for inorganics.

5.1.c Field Measurement of pH, and Specific Conductance and VOCs by Field GC

Level of QA effort for field measurement of pH will consist of precalibration using two buffer solutions and calibration verification at regular intervals (at least every ten samples).

Level of QA effort for specific conductance measurements will consist of initial and continuing (at least every ten samples) calibration verification using a standard solution of known conductivity.

Level of QA effort for the field GC will consist of initial calibration and continuing calibration verification afer every 10 samples. Maintenance and procedures of operation are described in Appendix G.

5.2 Accuracy, Precision and Sensitivity Analyses

Ten groundwater samples will be analyzed for EPA hazardous substances list (HSL) organics and inorganics (Tables A-1 and A-2) using the Contract Laboratory Program (CLP RAS). Eight sediment samples will be analyzed for VOCs only by CLP RAS. The QA objectives of analysis with respect to accuracy, precision and sensitivity are to achieve acceptable data based on specified performance criteria. Accuracy and precision requirements and method detection limits for CLP RAS protocol analysis are described in IFB's WA-85-J664/J680 for organics and WA-85-J838-J839 for inorganics. The remainder of the groundwater and surface water samples will be analyzed by CLP SAS. Accuracy and precision criteria and required detection limits for CLP SAS proposed analyses are listed with method descriptions in Appendix D.

Accuracy of field measured pH will be judged from agreement of instrument readings with standard buffer solutions. Agreement with standards will be within ±0.05 pH units and field measurements will be made to 0.01 unit. Measurement precision will be estimated by periodically (1 per 10 samples) making duplicate readings, which are expected to agree within 10 RPD. If the instrument fails to calibrate or meet performance criteria, it will be replaced.

Accuracy of the conductivity meter will be enhanced by initial and periodic calibration verification with a check standard solution. Precision will be estimated by making duplicate readings at a frequency of 1 per 10 samples. Agreement with the check standard will be within 5% or the instrument will be replaced.

Accuracy of the field GC will be assured by initial calibration and continuing calibration verification with a check standard. Precision will be estimated through analysis of duplicate samples. Specific performance criteria are listed with the method description in Appendix G.

<u>5.3 Completeness, Representativeness and Comparability</u>

It is anticipated that at least 95% of analyses will provide results meeting acceptance criteria. Sampling methods and locations are designed to provide results representative of the matrix at the sampling point. Analytical methods used will provide comparable data which will supplement prior data collected at the site.

<u>5.4 Field Measurements Not Involving Sample Collection</u>

Measurement data will be generated in many field activities that are incidental to collecting samples for analytical testing or unrelated to sampling. These activities include, but are not limited to, the following:

- Documenting time and weather conditions,
- Semi-quantitative total organic vapor screening of soil and water samples using a photoionization detector (e.g. HNu or equivalent) or a flame ionization detector (e.g. OVA)
- Determining depths in a borehole or well
- Natural gamma ray logging (Mount Sopris 1000C)
- Verifying well development and pre-sampling purge volumes

The general QC objective for such measurement data is to obtain reproducible and comparable measurements to a degree of accuracy consistent with the intended use of data through the documented use of standardized procedures.

Screening of soil and water samples and monitoring for health and safety purposes using photo-or flame-ionization detectors will be performed in accordance with manufactures instructions (see Appendices C-5, C-6 and C-7). Each will be calibrated prior to use. If instruments fail to calibrate, they will be replaced.

Depths will be determined by using a steel sounding device attached to a tape measure. Level of QA effect for these measurements will be limited to taking multiple readings at individual site locations.

Gamma ray logs will be made in accordance with manufacturers instructions. Level of QA effort will be limited to calibration prior to each logging to assess data comparability among boring locations.

Purge volumes will be estimated to the nearest gallon by collecting purge water in five gallon buckets.

6.0 Sampling Procedures

Procedures to sample soil, sediment, surface water and groundwater at the Sturgis Municipal Well field site are described in the Sampling Plan (Appendix B). Containers, preservatives, holding times, transport and storage methods are summarized in Table 6. Additional sample volumes (3X) will be taken for matrix spike/matrix spike duplicate analysis at a frequency of 1 per 20 samples.

7.0 Sample and Document Custody Procedures

7.1 Field Documentation

Chain of custody protocol used will follow guidelines detailed in NEIC Policies and Procedures, (EPA-330/9-78-001R, May 1978, Revised May 1986). This will include use of chain-of-custudy forms, custody seals, sample tags, organic and inorganics traffic reports, and field notebooks for sample documentation. The latter will include sampling time, location, tag numbers, samplers, pertinent PID readings, weather conditions and any field modifications of sampling strategy.

For field GC analyses, sample documentation will be limited to container labels and documentation in samplers and analysts notebooks. This documentation will include the transfer by the sampler and receipt by the analyst, respectively.

7.2 Laboratory Chain of Custody

All laboratory analyses will be performed by either CLP RAS or CLP SAS. Under this program, performing laboratories are required to have written and approved standard operating procedures detailing in-house sample documentation. Requirements include, at a minimum, sample tags, custody records, analysts logbook pages, bench sheets, chromatographic charts, computer printouts, raw data summaries, instrument logbook pages, correspondence and a document inventory.

7.3 Final Evidence File

All original data generated through the CLP will be retained by the EPA. Copies of CLP data and all original field data will be transferred to the MDNR. The MDNR will maintain and provide a custodian for the final evidence file. Upon completion of the project, MDNR will audit the evidence file to assure completeness.

8.0 Calibration Procedures, Frequency and Preventative Maintenance for Field Instruments

All instruments will be inspected and calibrated at Warzyn's analytical laboratory prior to being taken to the field. Calibration and maintenance of pH and specific conductance meters are detailed in Appendices C-1 through C-4. In the field, the pH meter will be calibrated using the two-buffer standardization method prior to use and recalibrated to pH 7 buffer every fifth sample. The conductivity meter will be tested daily using a check standard. If readings vary more than 5% from expected values the unit will be replaced.

The Field GC will be inspected and calibrated in the field pilot study. Calibration and maintenance of the field GC are discussed in Appendix G.

Calibration of survey instruments used for health and safety purposes will follow procedures recommended by the manufacturer (Appendices C-5 through C-7). The HNu and TIP will be calibrated at the beginning of each work day using standard calibration gas (isobutylane) supplied by HNu. The OVA will be calibrated once per month using methane as specified by the manufacturer, unless conditions warrant more frequent calibration. These conditions might include extensive use of instruments, particularly rough treatment or alteration of initial calibrations conditions.

9.0 Analytical Services

9.1 CLP RAS

A. Analytical and Calibration Procedures

Sediment samples collected during this project will be analyzed for HSL volatiles using CLP RAS (See Table A-1). Selected groundwater samples will be analyzed for the complete CLP HSL target compound list (Tables A-1 and A-2). All analyses will conform to the guidelines in the User's Guide to the U.S. EPA Contract Laboratory Program and to those specified in IFB's WA-85-J664/J680 or organics and WA-85-J838/J839 for inorganics. The analytical results for organics and inorganics in soil and sediment samples should be reported on dry-weight basis.

B. Internal Quality Control

Internal Quality Control procedures for sediments will follow the guidelines in the CLP and specified in IFB's WA-85-J664/J680 for organics and WA-85-J838/J839 for inorganics. Field and trip blanks and duplicates will be collected to check for any sample contamination resulting from field sampling equipment and to check data precision, respectively.

C. Performance and Systems Audit

Performance and systems audits for CLP, are the responsibility of the Support Services Branch, OERR, EPA and of EMSL-Las Vegas, EPA.

D. Data Assessment/Validation

The assessment/validation is the responsibility of CPMS and the CRL QC coordinator. The fraction of analysis results meeting specified QC-criteria (data completeness) will be checked by Warzyn and the SMO. Where test data have been reduced, the method of reduction will be described.

Data validation will be performed using guidelines developed in Technical Directive Document No. HQ-8410-01, Laboratory Data Validation, Functional Guildelines for Evaluating Organics Analyses, May, 1985, for organics analyses and those developed in Laboratory Data Validation, Functional Guidelines for Evaluating Inorganics Analyses, November, 1985, for inorganics.

E. Accuracy and Precision Definitions

Accuracy and precision definitions for analyses performed by CLP, RAS, are listed in IFB No.'s WA-85-J664/J680 and WA-85-J838/J839.

F. Corrective Action

If Quality Control Audits result in the detection of unacceptable conditions or data, the CPMS will be responsible for developing and initiating corrective action. The QAM will be notified if non-conformance is a program significance or requires special expertise not normally available to the project team. Corrective action may include:

- Re-analyzing the samples, if holding time criteria permits,
- Resampling and analyzing,
- Evaluating and amending sampling and analytical procedures, and/or
- Accepting data, acknowledging the level of uncertainty.

9.2 CLP SAS

A. Analytical and Calibration Procedures

Analytical procedures for samples analyzed by SAS are specified in SAS-Regional Request Forms (Appendix D). Any calibration of instruments will follow procedures specified in analysis methods cited, except where noted on SAS requests.

B. Internal Quality Control

Quality control requirements for each of the SAS analyses are specified in Appendix D. Field Blanks and duplicates will be collected and submitted for analysis to determine if any sample contamination is due to field sampling equipment and to check data precision, respectively.

C. Performance and Systems Audits

Systems audits and required performance limits are specified for each CLP, SAS analysis in Appendix D.

D. Data Assessment/Validation

The assessment/validation of data accuracy and precision is the responsibility of CPMS and CRL QC coordinator. The fraction of analyses results meeting specified QC-criteria (data completeness) will be checked by Warzyn and the SMO. Where test data have been reduced, the method of reduction will be described. Performance criteria for data validation are listed with methods descriptions in Appendix D.

E. Accuracy and Precision Definitions

Accuracy and precision definitions are specified for each CLP, SAS analysis in Appendix D.

F. Corrective Actions

If quality control audits detect unacceptable conditions or data, samples should be re-analyzed if holding time criteria permit. The Program Coordinator (Charles Elly or Jay Thakker) of the Contract Project Management Section will be contacted by the performing laboratory if requirements are not met upon reanalysis of samples.

10.0 Quality Assurance Reports

No separate QA report for this project is planned. The final RI report and FS report will contain separate sections that summarize quality of data collected during the project.

TABLE 1

HISTORICAL VOC CONCENTRATIONS (ug/l)
CITY WATER SUPPLY
STURGIS, MICHIGAN

Location / Date	Kirsch PW-3	Jackson PW-1	Layne PW-2	Oaklawn PW-5	Lakeview PW-4	City Hall* City Supply Location	Chicago Rd* City Supply Location
10-June-82	0-0-0	7-26-0	10-29-0			0-0-0	
29-June-82		0-74-0	0-11-0				
20-Aug-82	0-0-0	0-4-0	0-43-0			0-3-0	1-38-0
30-Sept-82		0-103-1	0-28-0				
11-Jan-83			9-2-0				
31-May-83		3-152-3	11-0-0				
9-Dec-83	0-0-0						
4-April-84				0-0-0			
6-April-84				0-0-0			
15-Jan-85	0-4-0				0-0-0		
29-Jan-85	0-3-0						
11-July-85	0-6-0			0-0-0	0-0-0		
13-May-86	0-6-0						

* these samples were taken from the municipal water supply system,
- the concentrations (ug/l) are in the following order: total trihalomethanes TCE-PCE

[jap-600-71a]

TABLE 2

Proposed Soil Gas Sampling Sites
Sturgis Well Field RI/FS

Location No.	Name/Type of Business	Total Number of Samples
1	Sturgis Tool and Die, Inc. 817 Broadus; 313 Susan Ct. (Metal Fabrication)	2
2	Kirsch Company 309 Prospect, 400 E. Hatch (Metal Fabrication)	15
3	Diamond Gear and Engineering 203 Ulm Street (Metal Fabrication)	3
4	Losinski Mold-Tool and Die 925 Clay Street (Metal Fabrication)	2
5	Sturgis Foundry Corporation 800 and 100 W. West St. (Foundry)	15
6	Disposal Area Behind Parma Tube Corporation 1008 W. Progress St. (Metal Fabrication)	3
7	Wade Electrical Products Company 211 Jacob St. (Electrical Parts, Solvent Distribution)	5
8	City Park West Power Plant (Possible former disposal site) 200 Blk. W. Chicago Road	4
9	Transogram-Midwest, Inc. 501 Jacob Street (Plastics and Metal Fabrication)	4
10	J&W Products, Inc. 807 W. West Street (Metal Fabrication)	3
11	Sturgis Electric Motor Service 703 N. Centerville Road (Motor repairs, metalizing)	2

Table 2 (continued)

Location No.	Name/Type of Business	Total Number of Samples
12	United Paper Company 1 United Drive (Paper Products)	5
13	Bandholtz Paint Mfg. Co. 121 N. Nottawa St. 106 Pleasant Avenue (Paints and Solvents)	9
14	Area of McKee and Centerville Rd Numerous Metal Fabrications	10
	Total Number of Samples	82

[sss-600-49b]

TABLE 3

Proposed Well Locations and Their Rationale
Sturgis Well Field RI/FS

Well No.1	Total Drilling (ft)	Rationale
W-1S, D*	200	To examine water quality on the former site of a potential TCE user.
W-2S, D	200	To characterize groundwater flow and water quality to the east of the contaminated power plant (Jackson and Layne) wells in the vicinity of a potential source area.
W-3S	50	With TW-83A, will examine groundwater flow parameters at a location between industrial pumping wells (R-wells) and the power plant wells.
W-4S	50	To augment an existing monitoring well installed by Gove Associates, Inc. W-4S will monitor groundwater flow in the upper aquifer.
W-5D	150	To augment an existing monitoring well installed by Gove Associates, Inc., W-5D will monitor groundwater flow and water quality in the lower aquifer.
W-6S, D	200	To characterize general water quality and vertical hydraulic gradients to the northeast of contaminated municipal Well PW-3.

TABLE 3
(Continued)

W-7S, D	200	To examine water quality and groundwater flow to the west of a series of contaminated industrial water supply wells in an industrial park with several potential source areas.
Total with Planned Locations	1050	
Discretionary		
W-8S,D	200	
W-9S,D	200	
W-10S,D	200	
W-11D	150	
Total Discretionary	1800	

1. Nested wells designated as

   S - Shallow well in the upper aquifer - 50 feet deep
   D - Deep well in the lower aquifer - 150 feet deep

2. Total discretionary drilling footage is based on unit costs for drilling and well placement specified. Actual number and depth of wells implemented in the field may be different.

TABLE 4
SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
STURGIS MUNICIPAL WELL FIELD

Matrix 1)	Field Parameters 2)	Lab 3)	Number of Samples	Duplicates	Field(7) Blanks	Trip(7) Blanks	MS/MSD 4)	Matrix Total 5)	Test Parameters 6)
Groundwater existing wells, Subtask 4.2, Phase I	pH specific conductivity, temperature	CLP SAS CLP SAS	23 23	3 3	3 3	2	2 4**	35 29	VOC Akal., Sulfate Chloride, Nitrate + Nitrite, TKN, TOC, Ca, Mg
Groundwater new and existing wells Subtask 4.6 Round One	pH specific conductivity, temperature	CLP SAS CLP SAS	49 49	5 5	5 5	3	3 **	65 59	VOC Akal., Sulfate Chloride, Nitrate & Nitrite, TKN, TOC Ca, Mg
		CLP RAS	10	1	1	1	1	14	VOCs consistent with CLP RAS protocols BNA extractables consistent with CLP RAS protocols Pesticides/PCBs consistent with CLP RAS protocols Metals consistent with CLP RAS protocols filtered samples Cyanide consistent with CLP RAS protocols
Surface Water Subtask 4.5 Phase I	pH, specific conductivity temperature	CLP SAS	8	1	1	1	2	13	VOC
Sediment Subtask 4.5 Phase I		CLP RAS	8	1	1	1	2	13	VOC
Soil Gas Subtask 4.3 Phase I	On-site GC VOC-screen	Field GC	82	*	*		*	82+	VOC
Groundwater during drilling Subtask 4.4 Phase I	On-site GC VOC-screen	Field GC CLP SAS	81 38	8* 4	8* 4	3	2	97 49	VOC VOC
Groundwater new and existing wells, Subtask 4.6, Round Two	pH, specific conductivity, temperature	CLP SAS CLP SAS	49 49	5 5	5 5	3	3 **	65 59	VOC Akal., Sulfate, Chloride, Nitrate & Nitrite, TKN, TOC, Ca, Mg

* Duplicates, blanks and spikes will be analyzed on a per day basis for on-site GC analyses as outined in Appendix G.
** As outlined in Appendix D SAS requests.

SUMMARY OF SAMPLING
(cont.)

1) All samples are to be considered low concentration

2) Field parameters run by Warzyn sampling personnel
All samples for metal analysis will be filtered prior to preservation.

3) Contract Laboratory Program, RAS, SAS

4) Triple of normal volume will be collected for matrix spike/matrix spike duplicate analysis

5) Matrix totals include extra samples required for matrix spike/ matrix spike duplicate analyses for organics.

6) See Appendix D for requested analysis methods.

7) Field and trip blank numbers are estimated. Actual numbers may vary based on field conditions.

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[sss-600-49d]

TABLE 5
PROJECT SCHEDULE
STURGIS WELL FIELD RI/FS

TASKS : 1 2 3 4 : 5 6 7 8 : 9 10 11 12 : 13 14 15 16 : 17 18 19 20 : 21 22 23 24 : 25 26 27 28 : 29 30 31 32 : 33 34 35 36 : 37 38 39 40

REMEDIAL INVESTIGATION

TASK 2-PLANS AND MANAGEMENT

2.1-WORK PLAN
2.2-QAPP
2.3-SAMPLING PLAN
2.4-HEALTH/SAFETY PLAN
2.5-DATA MGT PLAN

TASK 3-PRELIMINARY EVALUATION

3.1-INDUSTRIAL SURVEY
3.2-PRELIMINARY MODEL

TASK 4-PHASE I INVESTIGATION

4.1-PREPARATION
4.2-EXISTING WELL SAMPLING
4.3-SOIL GAS SAMPLING
4.4-WELL DRILLING
4.5-SURFACE WATER AND SEDIMENT
4.6-GROUNDWATER SAMPLING
4.7 GROUNDWATER LEVELS
4.8-TOPOGRAPHIC SURVEY
4.9 INTERIM RI ANALYSIS

TASK 5-PHASE II INVESTIGATION

TASK 6-COMMUNITY RELATIONS

TASK 7-RI REPORT

TASK 8 RI PROJECT MANAGEMENT

FEASIBILITY STUDY

TASK 9-WORK PLAN REVISION

TASK 10-EXPOSURE ASSESSMENT

TASK 11-PRELIM. REM. TECHNOLOGY

TASK 12-DEVELOP ALTERNATIVES

TASK 13-INITIAL SCREENING

TASK 14-EVAL. OF ALTERNATIVES

TASK 15-EVAL. OF COST EFF. ALT.

TASK 16-DRAFT FS REPORT

TASK 17-FINAL FS REPORT

---- - PROJECT ACTIVITIES
!!!! - LAB TURNAROUND TIME
* - MEETING

TABLE 5 (continued)
PROJECT SCHEDULE
STURGIS WELL FIELD RI/FS

TASKS	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
REMEDIAL INVESTIGATION																																												
TASK 2-PLANS AND MANAGEMENT																																												
2.1-WORK PLAN																																												
2.2-QAPP																																												
2.3-SAMPLING PLAN																																												
2.4-HEALTH/SAFETY PLAN																																												
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4.3-SOIL GAS SAMPLING																																												
4.4-WELL DRILLING																																												
4.5-SURFACE WATER AND SEDIMENT																																												
4.6-GROUNDWATER SAMPLING	!!!!	!!!!	!!!!	!!!!	!!!!	!!!!																																						
4.7 GROUNDWATER LEVELS																																												
4.8-TOPOGRAPHIC SURVEY																																												
4.9 INTERIM RI ANALYSIS																																												
TASK 5-PHASE II INVESTIGATION																																												
TASK 6-COMMUNITY RELATIONS	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----				
TASK 7-RI REPORT						----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----						*	----	----	----											
TASK 8 RI PROJECT MANAGEMENT	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----															
FEASIBILITY STUDY																																												
TASK 9-WORK PLAN REVISION													----	----	----		*																											
TASK 10-EXPOSURE ASSESSMENT																		----	----	----	----	----	----	----		*																		
TASK 11-PRELIM. REM. TECHNOLOGY																					----	----	----	----																				
TASK 12-DEVELOP ALTERNATIVES																						----	----	----	----																			
TASK 13-INITIAL SCREENING																								----	----																			
TASK 14-EVAL. OF ALTERNATIVES																									----	----	----	----	----															
TASK 15-EVAL. OF COST EFF. ALT.																														----	----	----												
TASK 16-DRAFT FS REPORT																									----	----	----	----	----	----	----	----	----	----	----	----	*							
TASK 17-FINAL FS REPORT																																					----	----	----	----				

---- - PROJECT ACTIVITIES
!!!! - LAB TURNAROUND TIME
* - MEETING

TABLE 6

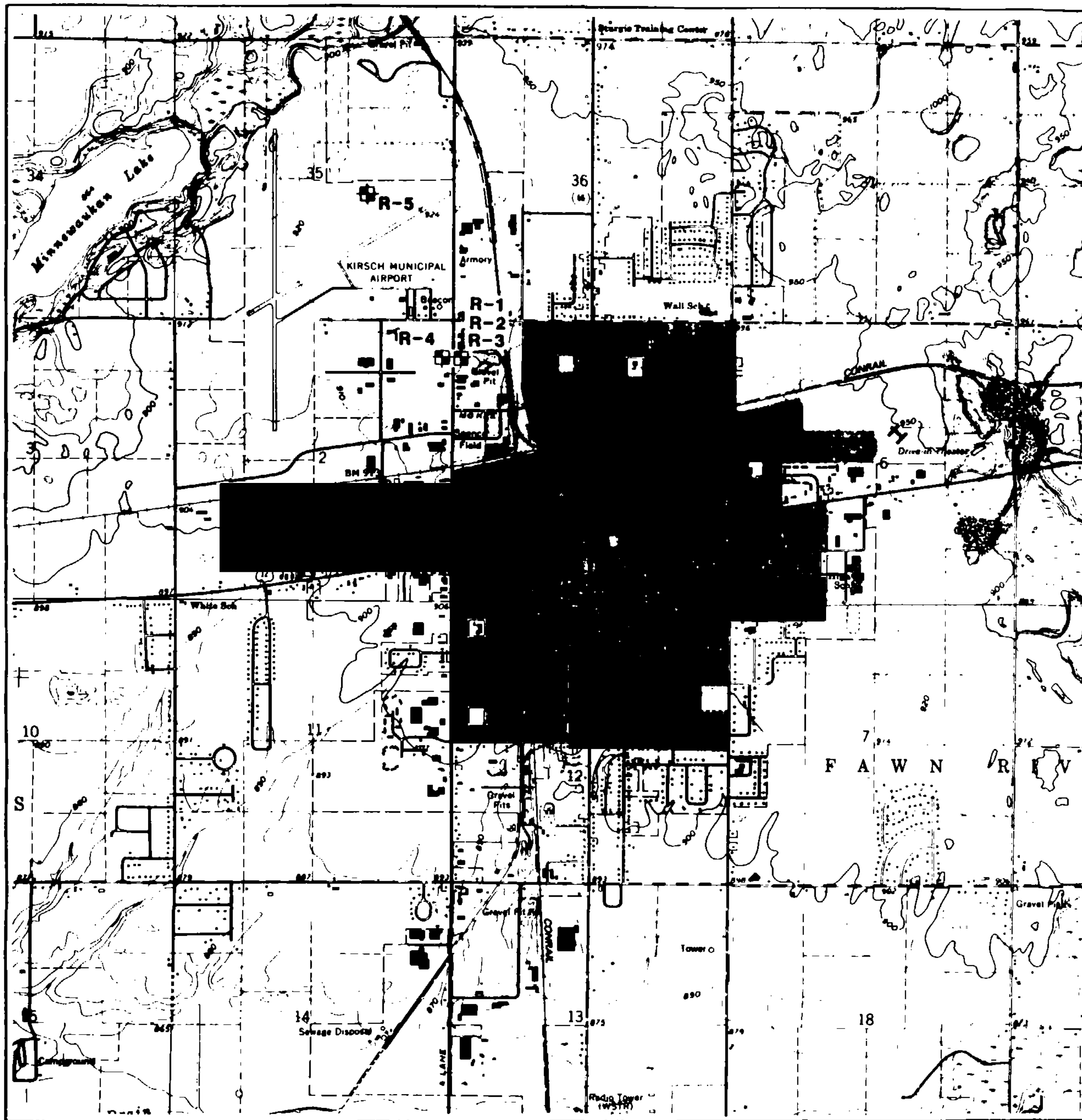
SAMPLE QUANTITIES, BOTTLES, PRESERVATIVES AND PACKAGING
FOR SOIL, SEDIMENT AND WATER SAMLES FROM STURGIS MUNICIPAL WELL FIELD

Analysis	Bottles and Jars	Preservation	Holding time	Volume of Samples	Shipping	Normal Packaging
WATER AND LIQUIDS						
Routine Analytical Services (RAS) Low Concentration (Organics)						
Acid Extractables, base/neutral extractables, pesiticides/PCBs	Two 80 oz. amber bottles (teflon-lined caps)	Iced to 4°C	5 days until extraction	Fill bottle to neck	Federal Express Priority I	No. 1 foam liner or vermiculite
Volatiles	One 120-ml volatile organic analysis	Iced to 4°C	7 days	Fill completely no headspace	Federal Express Priority I	No. 1 foam liner or vermiculite
Low Concentration (Inorganics)						
Metals	One 1-liter high density polyethylene bottle	Filter through 0.45 um filter HNO_3 to pH <2 Iced to 4°C	6 months	Fill to shoulder of bottle	Federal Express Priority I	No. 2 foam liner or vermiculite
Cyanide	One 1-liter high density polyethylene bottle	6N to pH >12 NaOH, Iced to 4°C	14 days	Fill to shoulder of bottle	Federal Express Priority I	No. 2 foam liner or vermiculate

TABLE 6
(cont.)

Analysis	Bottles and Jars	Preservation	Holding time	Volume of Samples	Shipping	Normal Packaging
Special Analytical Services (SAS) Water Low Concentration (Organics)						
Volatiles	One 120-ml volatile organic analysis (VOA vials)	Iced to 4°C	7 days	Fill completely no headspace	Delivered daily to performing laboratory	No. 1 foam liner or vermiculite
Low Concentration (Inorganics)						
TKN, TOC, Nitrate + Nitrite-N	One 1-liter high density polyethylene bottle	1:1 H_2SO_4 to pH <2 Iced to 4°C	28 days	Fill to shoulder of bottle	Federal Express Priority I	Vermiculite
Sulfate, Chlorides, Alkalinity	One 1-liter high density polyethylene	Iced to 4°C	28 days (14 days for alkalinity)	Fill to shoulder of bottle	Federal Express Priority I	No. 2 foam liner or vermiculite
Metals	One 1-liter high density ployethylene	Filtered through 0.45 um filter, 1:1 HNO_3 to pH <2 Iced to 4°C	6 months	Fill to shoulder of bottle	Deliver daily to performing Laboratory	Vermiculite
SOILS AND SOLIDS						
Routine Analytical Services (RAS) Low or Med Concentration (Organics)						
Volatiles	Two 120-ml VOA vials	Iced to 4°C	7 days	Fill completely no headspace	Federal Express Priority I (Med w/attached shipper's certificate for restricted articles)	Vermiculite (Med in cans/ vermiculite)

[sss-600-49f]



NOTES:

1. SITE LOCATION MAP OBTAINED FROM U.S.G.S. 7 1/2 MINUTE QUADRANGLE MAP STURGIS, MICHIGAN - INDIANA DATED 1961 PHOTOREVISED 1982.

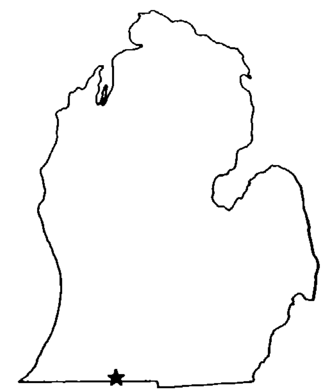
2. CONTOURS INTERVAL IS 10 FEET

3. REFER TO STANDARD U.S.G.S. MAP SYMBOLS.

4. R SERIES WELLS - INDRUSTRIAL WATER SUPPLY WELLS. PW-1 - JACKSON WELL. PW-2 - LAYNE WELL PW-3 - KIRSCH WELL. PW-4 - LAKEVIEW WELL. PW-5 - OAKLAWN WELL.

LEGEND:

APPROXIMATE PUMPING WELL LOCATIONS



north

FIG. 1

WARZYN

SITE LOCATION MAP
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
STURGIS WELL FIELD
STURGIS, MICHIGAN

DRAWN	CHECKED	APPROVED	DATE	SCALE	DRAWING NO
ALH	TEM	Ken Dunn	7/22/87	1"=2000'	12686-B1

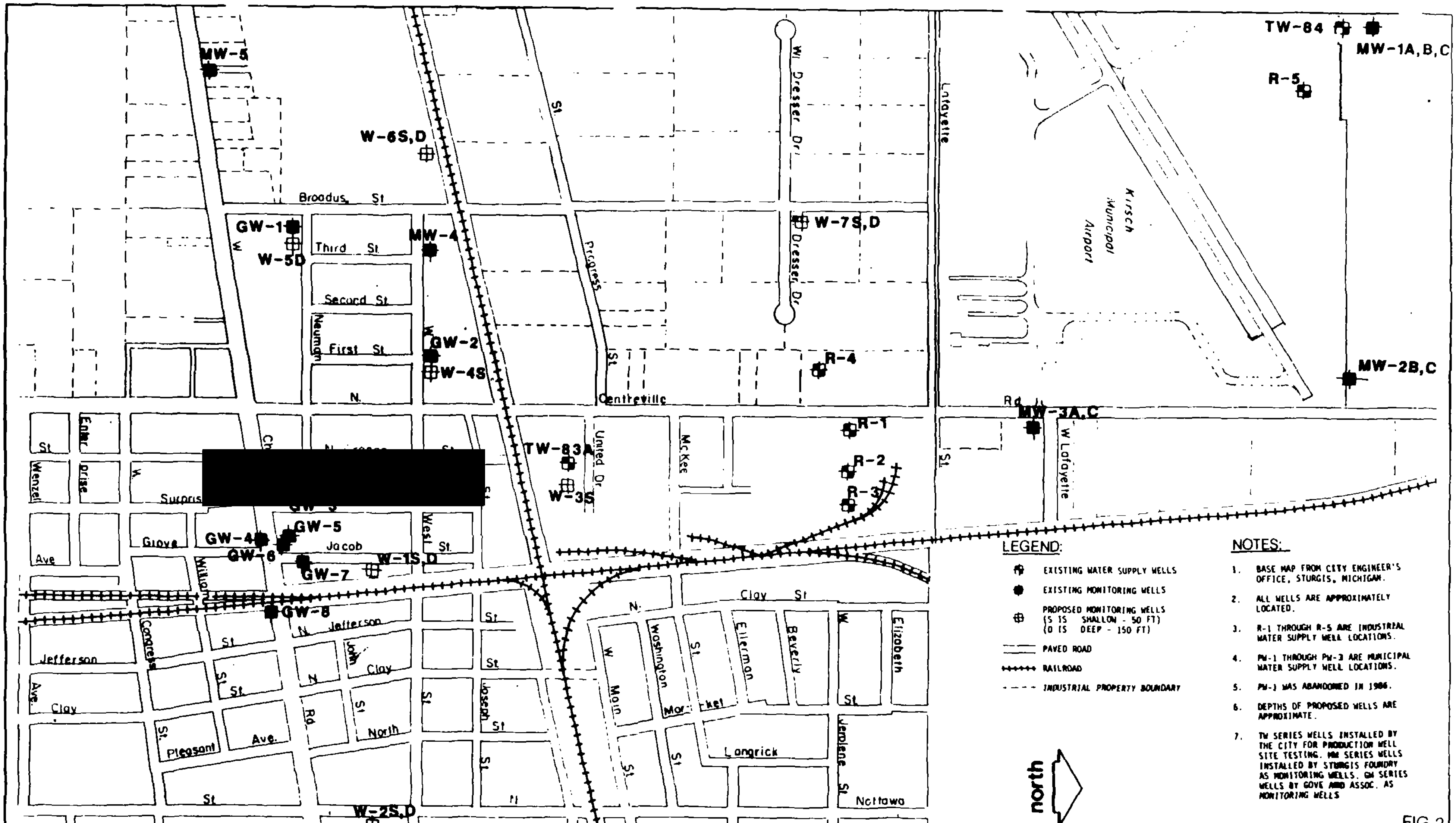


FIG. 2

WARZYN

PROPOSED WELL LOCATIONS

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
STURGIS WELL FIELD
STURGIS, MICHIGAN

DRAWN	CHECKED	APPROVED	DATE	SCALE	DRAWING NO
ALH	TEM	[signature]	7/2/87	1" = 600'	12686-B2

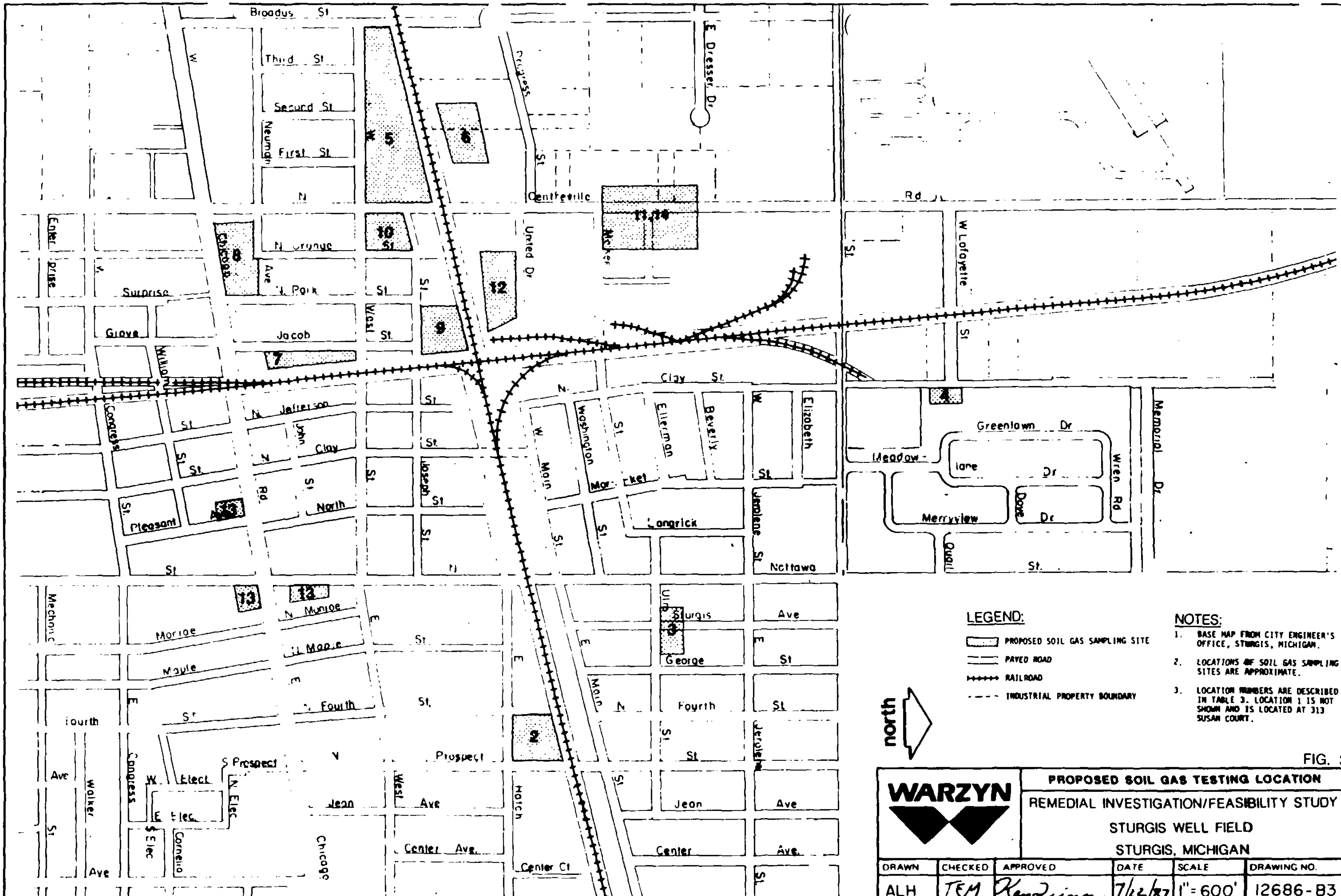


FIG. 3

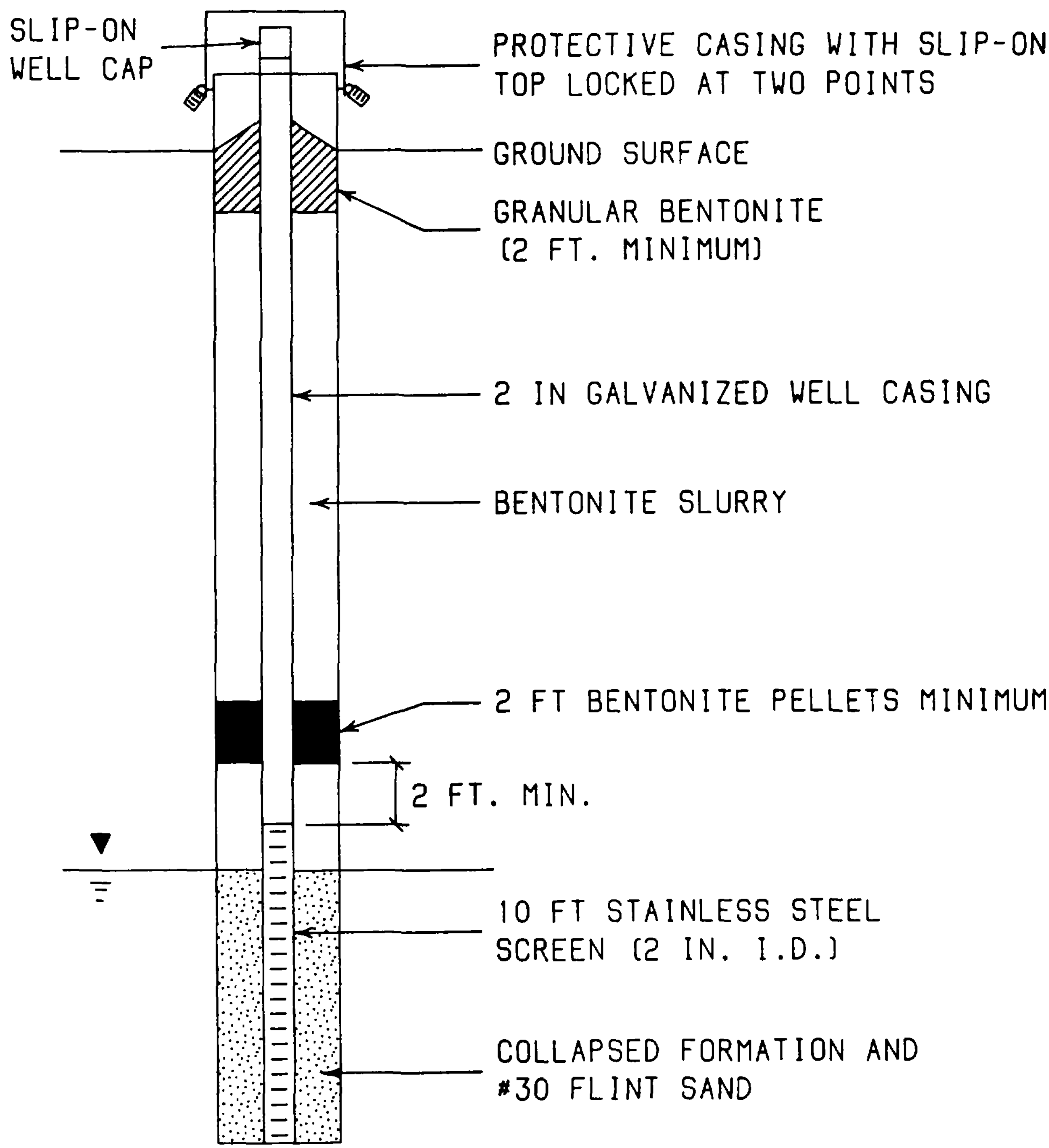
WARZYN

PROPOSED SOIL GAS TESTING LOCATION

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
STURGIS WELL FIELD
STURGIS, MICHIGAN

DRAWN	CHECKED	APPROVED	DATE	SCALE	DRAWING NO.
ALH	TEM	Ken Quinn	7/22/87	1" = 600'	12686-B3

TELEDYNE POST N75674

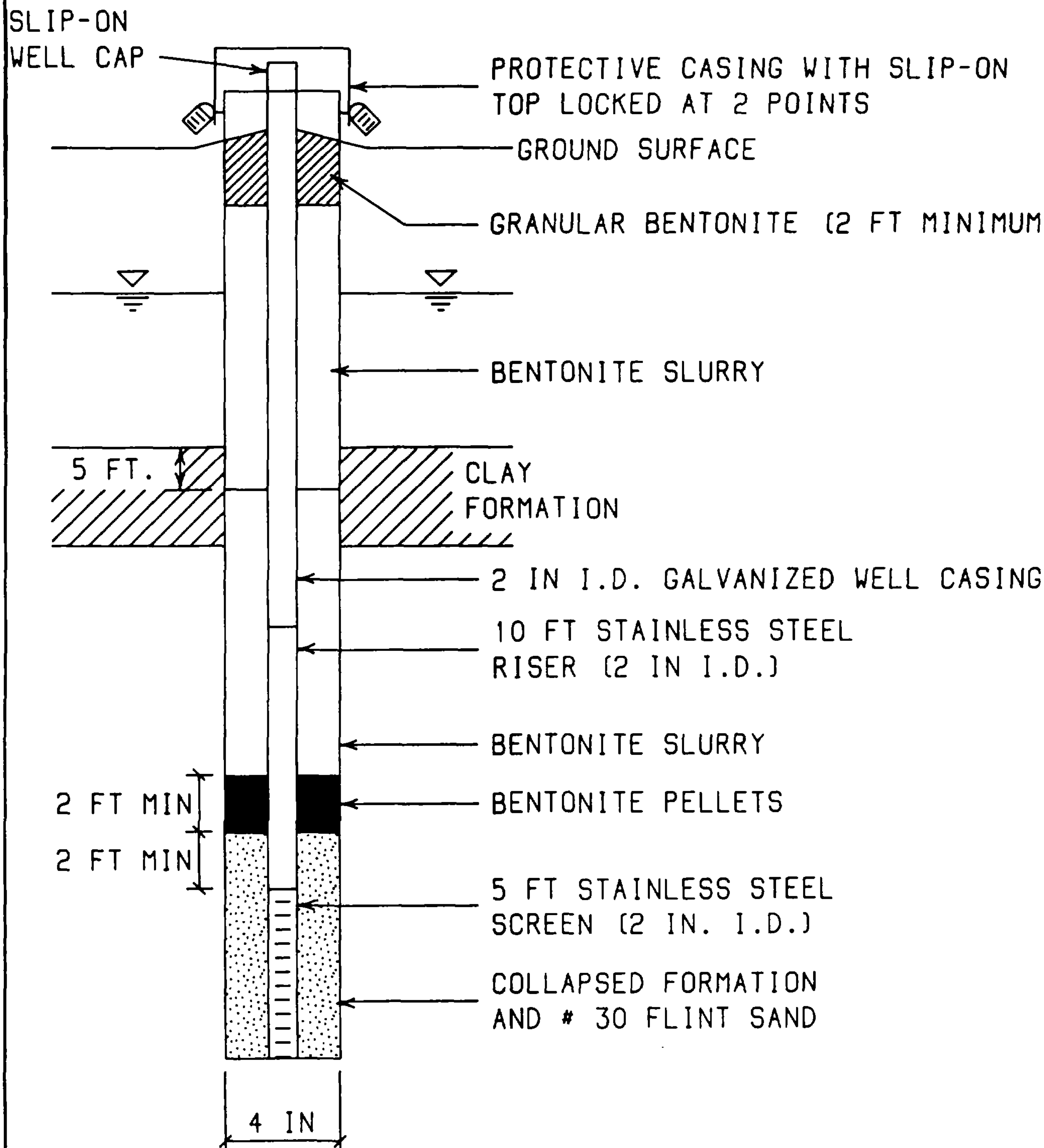


NOT TO SCALE

FIG.4

WARZYN ENGINEERING INC	**WATER TABLE (SHALLOW) WELL**
	REMEDIAL INVESTIGATION/FEASIBILTY STUDY STURGIS WELL FIELD STURGIS, MICHIGAN

DWN ALH	CHK D TEM	APP D	DATE 2/22/87	C12686-A1



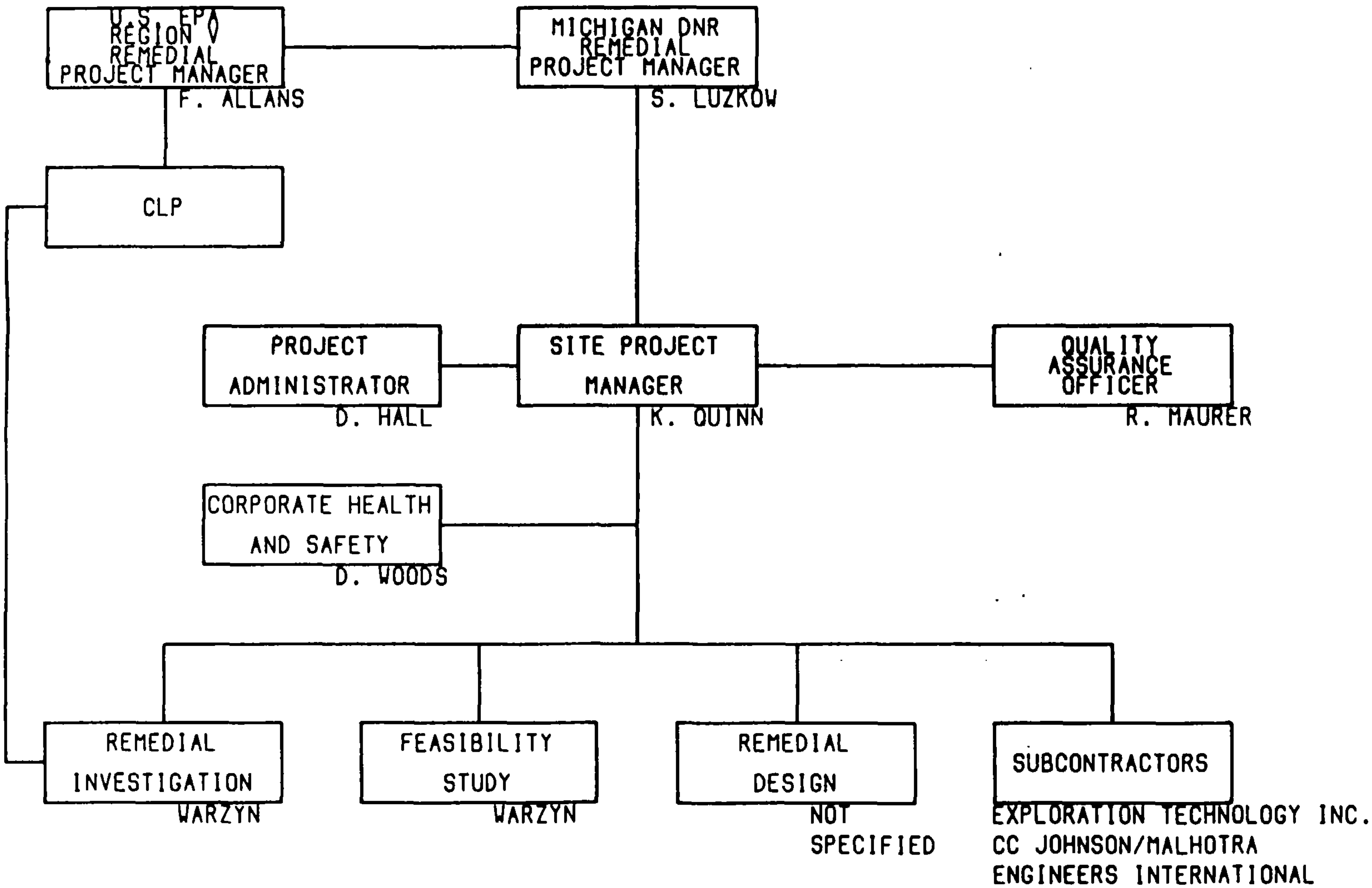
NOT TO SCALE

FIG.5

WARZYN ENGINEERING INC	**DEEP (PIEZOMETER) WELL** REMEDIAL INVESTIGATION/FEASIBILTY STUDY STURGIS WELL FIELD STURGIS, MICHIGAN

DWN ALH	CHK'D	APP'D	DATE 7/22/87	C12686-A2

FIGURE 6
PROJECT ORGANIZATION CHART
STURGIS



A

APPENDIX A

EPA HSL - RAS
ORGANIC AND INORGANICS

TABLE A-1

CLP TARGET COMPOUND LIST AND
CONTRACT REQUIRED DETECTION LIMITS (CRDL)*

	Volatiles	CAS Number	Detection Limits(1) Low Water(2) ug/l	Low Soil Sediment(3) ug/kg
1.	Chloromethane	74-87-3	10	10
2.	Bromomethane	74-83-9	10	10
3.	Vinyl Chloride	75-01-4	10	10
4.	Chloroethane	75-00-3	10	10
5.	Methylene Chloride	75-09-2	5	5
6.	Acetone	67-64-1	10	10
7.	Carbon Disulfide	75-15-0	5	5
8.	1,1-Dichloroethene	75-35-4	5	5
9.	1,1-Dichloroethane	75-35-3	5	5
10.	trans-1,2-Dichloroethene	156-60-5	5	5
11.	Chloroform	67-66-3	5	5
12.	1,2-Dichloroethane	107-06-2	5	5
13.	2-Butanone	78-93-3	10	10
14.	1,1,1-Trichloroethane	71-55-6	5	5
15.	Carbon Tetrachloride	56-23-5	5	5
16.	Vinyl Acetate	108-05-4	10	10
17.	Bromodichloromethane	75-27-4	5	5
18.	1,1,2,2-Tetrachloroethane	79-34-5	5	5
19.	1,2-Dichloropropane	78-87-5	5	5
20.	trans-1,3-Dichloropropene	10061-02-6	5	5
21.	Trichloroethene	79-01-6	5	5
22.	Dibromocloromethane	124-48-1	5	5
23.	1,1,2-Trichloroethane	79-00-5	5	5
24.	Benzene	71-43-2	5	5
25.	cis-1,3-Dichloropropene	10061-01-5	5	5
26.	2-Chloroethyl Vinyl Ether	110-75-8	10	10
27.	Bromoform	75-25-2	5	5
28.	2-Hexanone	591-78-6	10	10
29.	4-Methyl-2-pentanone	108-10-1	10	10
30.	Tetrachloroethene	127-18-4	5	5
31.	Toluene	108-88-3	5	5
32.	Chlorobenzene	108-90-7	5	5
33.	Ethyl Benzene	100-41-4	5	5
34.	Styrene	100-41-4	5	5
35.	Total Xylenes	100-42-5	5	5

Table A-1, continued

	Semi-Volatiles	CAS Number	Detection Limits(1) Low Water(4) ug/l	Low Soil Sediment(5) ug/kg
36.	Phenol	108-95-2	10	330
37.	bis(2-Chloroethyl)ether	111-44-4	10	330
38.	2-Chlorophenol	95-57-8	10	330
39.	1,3-Dichlorobenzene	541-73-1	10	330
40.	1,4-Dichlorobenzene	106-46-7	10	330
41.	Benzyl Alcohol	100-51-6	10	330
42.	1,2-Dichlorobenzene	95-50-1	10	330
43.	2-Methylphenol	95-48-7	10	330
44.	bis(2-Chloroisopropyl)ether	39638-32-9	10	330
45.	4-Methylphenol	106-44-5	10	330
46.	N-Nitroso-Dipropylamine	621-64-7	10	330
47.	Hexachloroethane	67-72-1	10	330
48.	Nitrobenzene	98-95-3	10	330
49.	Isophorone	78-59-1	10	330
50.	2-Nitrophenol	88-75-5	10	330
51.	2,4-Dimethylphenol	105-67-9	10	330
52.	Benzoic Acid	65-85-0	50	1600
53.	bis(2-Chloroethoxy)methane	111-91-1	10	330
54.	2,4-Dichlorophenol	120-83-2	10	330
55.	1,2,4-Trichlorobenzene	120-82-1	10	330
56.	Naphthalene	91-20-3	10	330
57.	4-Chloroaniline	106-47-8	10	330
58.	Hexachlorobutadiene	87-68-3	10	330
59.	4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
60.	2-Methylnaphthalene	91-57-6	10	330
61.	Hexachlorocyclopentadiene	77-47-4	10	330
62.	2,4,6-Trichlorophenol	88-06-2	10	330
63.	2,4,5-Trichlorophenol	95-95-4	50	1600
64.	2-Chloronaphthalene	91-58-7	10	330
65.	2-Nitroaniline	88-74-4	50	1600
66.	Dimethyl Phthalate	131-11-3	10	330
67.	Acenaphthylene	208-96-8	10	330
68.	3-Nitroaniline	99-09-2	50	1600
69.	Acenaphthene	83-32-9	10	330
70.	2,4-Dinitrophenol	51-28-5	50	1600
71.	4-Nitrophenol	100-02-7	50	1600
72.	Dibenzofuran	132-64-9	10	330
73.	2,4-Dinitrotoluene	121-14-2	10	330
74.	2,6-Dinitrotoluene	606-20-2	10	330
75.	Diethylphthalate	84-66-2	10	330

Table A-1, continued

	Semi-Volatiles	CAS Number	Detection Limits[1] Low Water[4] ug/l	Low Soil/Sediment[5] ug/kg
76.	4-Chlorophenyl Phenyl ether	7005-72-3	10	330
77.	Fluorene	86-73-7	10	330
78.	4-Nitroaniline	100-01-6	50	1600
79.	4,6-Dinitro-2-methylphenol	534-52-1	50	1600
80.	N-nitrosodiphenylamine	86-30-6	10	330
81.	4-Bromophenyl Phenyl ether	101-55-3	10	330
82.	Hexachlorobenzene	118-74-1	10	330
83.	Pentachlorophenol	87-86-5	50	1600
84.	Phenanthrene	85-01-8	10	330
85.	ANTHRACENE	120-12-7	10	330
86.	Di-n-butylphthalate	84-74-2	10	330
87.	Fluoranthene	206-44-0	10	330
88.	Pyrene	129-00-0	10	330
89.	Butyl Benzyl Phthalate	85-68-7	10	330
90.	3,3'-Dichlorobenzidine	91-94-1	20	660
91.	Benzo(a)anthracene	56-55-3	10	330
92.	bis(2-ethylhexyl)phthalate	117-81-7	10	330
93.	Chrysene	218-01-9	10	330
94.	Di-n-octyl Phthalate	117-84-0	10	330
95.	Benzo(b)fluoranthene	205-99-2	10	330
96.	Benzo(k)fluoranthene	207-08-9	10	330
97.	Benzo(a)pyrene	50-32-8	10	330
98.	Indeno(1,2,3-cd)pyrene	193-39-5	10	330
99.	Dibenz(a,h)anthracene	53-70-3	19	330
100.	Benzo(g,h,i)perylene	191-24-2	10	330

Table A-1, continued

	Pesticides	CAS Number	Detection Limits(1) Low Water(6) ug/l	Low Soil Sediment(7) ug/kg
101.	alpha-BHC	319-84-6	0.05	8.0
102.	beta-BHC	319-85-7	0.05	8.0
103.	delta-BHC	319-86-8	0.05	8.0
104.	gamma-BHC (Lindane)	58-89-9	0.05	8.0
105.	Heptachlor	76-44-8	0.05	8.0
106.	Aldrin	309-00-2	0.05	8.0
107.	Heptachlor Epoxide	1024-57-3	0.05	8.0
108.	Endosulfan I	959-98-8	0.05	8.0
109.	Dieldrin	60-57-1	0.10	16.0
110.	4,4'-DDE	75-55-9	0.10	16.0
111.	Endrin	72-20-8	0.10	16.0
112.	Endosulfan II	33213-65-9	0.10	16.0
113.	4,4-DDD	72-54-8	0.10	16.0
114.	Endosulfan Sulfate	1031-07-8	0.10	16.0
115.	4,4'-DDT	50-29-3	0.10	16.0
116.	Endrin Ketone	53494-70-5	0.10	16.0
117.	Methoxychlor	72-43-5	0.5	80.0
118.	Chlordane	57-74-9	0.5	80.0
119.	Toxaphene	8001-35-2	1.0	160.0
120.	AROCLOR-1016	12674-11-2	0.5	80.0
121.	AROCLOR-1221	11104-28-2	0.5	80.0
122.	AROCLOR-1232	11141-16-5	0.5	80.0
123.	AROCLOR-1242	53469-21-9	0.5	80.0
124.	AROCLOR-1248	12672-29-6	0.5	80.0
125.	AROCLOR-1254	11097-69-1	1.0	160.0
126.	AROCLOR-1260	11096-82-5	1.0	160.0

NOTES

(1) Detection limits listed for soil/sediment are based on net weight. The detection limits calculated by the laboratory for soil/sediments will be on dry weight basis and will be higher.

(2) Medium Water Contract Required Detection Limits (CRDL) for Volatile Hazardous Substances List (HSL) Compounds are 100 times the individual Low Water DL.

(3) Medium Soil/Sediment CRDL for Volatile HSL Compunds are 100 times the individual Low Water CRDL.

(4) Medium Water CRDL for Semi-Volatile HSL Compounds are 100 times the individual Low Water CRDL.

(5) Meidum Soil/Sediment CRDL for Semi-Volatile HSL Compunds are 60 times the individual Low Soil/Sediment CRDL.

(6) Medium Water CRDL for Pesticide HSL Compounds are 100 times the individual Low Water CRDL.

(7) Medium Soil/Sediment CRDL for Pesticide HSL Compunds are 15 times the individual Low Soil/Sediment CRDL.

* Specific detection limits are highly matrix dependent. The detection limit listed herein are provided for guidance and may not always be achievable.

[sss-600-48a]

TABLE A-2

ELEMENTS DETERMINED BY INDUCTIVELY COUPLED PLASMA EMISSION OR ATOMIC ABSORPTION SPECTROSCOPY

Metal	Required Detection Level(1)(2) ug/l
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Other	
Cyanide	10

NOTES

(1) Any analytical method specified in Exhibit D of IFB WA 84-J091/J092 may be utilized as long as the documented instrument or method detection limits meet the CRDL requirements. Higher detection levels may only be used in the following circumstances.

If the sample concentration exceeds two times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the CRDL.

[sss-600-48b]

B

APPENDIX B

SAMPLING PLAN

SAMPLING PLAN
THE STURGIS WELL FIELD RI/FS
12686

I. OBJECTIVE

This sampling plan details the procedures and practices to be used in obtaining groundwater, surface water, sediment and soil gas samples for Phase I of the Sturgis Well Field RI/FS. Groundwater sampling is further subdivided into sampling and analysis during drilling as a screening tool, and sampling as a water quality monitoring process. Approximately 81 water samples will be analyzed by field GC while drilling, 23 wells will be sampled and analyzed to establish existing site conditions, and 49 wells will be sampled and analyzed per sampling round of water quality monitoring subsequent to monitoring well installation. Eight surface water and eight sediment samples, both from potential surface effluent discharge points, will be collected and analyzed. Finally, approximately 82 soil gas samples will be collected and analyzed during source investigation/characterization activities.

II. SAMPLING LOCATIONS AND NUMBER OF SAMPLES

A. Sampling Locations

Groundwater, surface water, sediment and soil gas samples will be collected at various locations in the City of Sturgis. Specific locations and numbers of samples to be obtained follow. A summary of sample numbers and required numbers of quality control samples is given in Task 4 of the QAPP.

B. Well Drilling

Eighty one (81) groundwater samples will be collected during drilling and analyzed for VOCs using a field GC. Results will be used to aid in the selection of well screen intervals. Thirty eight (38) of the above samples will be analyzed for VOCs by CLP SAS to provide confirmation data.

WARZYN

C. Groundwater Samples

Groundwater monitoring will consist of an initial round of sampling at selected existing monitoring wells (10 total), at two (2) test wells, and at eleven (11) production wells. Samples will be analyzed for VOCs and selected indicator parameters. To obtain lower detection limits than those available by CLP protocols, VOCs will be analyzed by CLP SAS using a requested analysis method.

Groundwater samples will also be collected during two rounds of groundwater quality monitoring from the following locations:

- 11 municipal and industrial water supply wells;
- 20 monitoring and test wells which were installed during previous TCE and water supply investigations;
- 18 wells installed by Warzyn Engineering Inc. during the Phase I investigative effort.

These samples will be anallyzed for VOCs by CLP SAS and for selected indicator parameters.

D. Surface Water and Sediment Samples

Eight surface water and sediment samples will be collected from the following effluent discharge and disposal pits:

- The Kirsch Company effluent discharge;
- The Sturgis Foundry seepage lagoon;
- The gravel pit along the south side of the Ross Laboratory building;
- A disposal pit located north of Sturgis Foundry and south of Parma Tube Corporation;

A distribution of samples between the four locations will be based on results of the industrial site surveys and will be approved by the MDNR project manager.

E. Soil Gas Sampling

Up to 82 gas samples will be collected from 14 locations where TCE has or may have been used. The soil gas survey will help to identify and characterize possible source areas. Figure 3 of the QAPP shows the locations of the soil gas test points. Sample blanks, duplicates and matrix spikes will also be collected (see Table 4).

III. SAMPLE DESIGNATION

A sample numbering system will be used to identify each sample, duplicate and blank. Each sample identifier will include the project identifier code, sample type and location code, and a sampling event code. The team leader will maintain a log book containing the sample identification listings.

A. Project Identifier Code

A 2-letter designation will be implemented to identify the sampling site. The project identifier will include "S" for the Sturgis Well Field project following by "M" for Michigan Department of Natural Resources lead project.

B. Sample Type and Location Code

Each sample collected will be identified by a 1- or 2-digit code corresponding to the sample type. The location code, as shown on Figures 1 and 2 will follow the sample type code. The sample type codes are:

- GW or MW - groundwater sample
- S - selected soil boring sample
- W - surface water sample
- SD - sediment sample
- SG - soil gas sample
- SB - sample blank
- BB - bottle blank

All sample location and well numbers will be modified from Figures 1 and 2 to be numbered 01, 02, 03 ... 09, 10, 11, ... etc.

Water quality samples collected during drilling will have an additional numerical code numbered consecutively from the surface.

C. Sampling Event Code

All samples except soils obtained during drilling will have a numeric identifier to signify the sampling event. Duplicate samples will be identified with a "D".

D. Examples of Sample Numbers

Examples of sample number codes are as follows:

- SM-GW07-01 = Sturgis, monitoring well groundwater sample from GW7, sampling period 1;
- SM-MW05-02 = Sturgis, groundwater sample No. 2, collected during drilling Well MW5, Period 1.
- SM-W02-D2 = Sturgis, surface water location 2, duplicate, sample period 2;
- SM-SB10-01 = Sturgis, sample blank number 10, sampling period 1;
- SM-SG05-01 = Sturgis, soil gas sample from location 05, sample period 1.

IV. GENERAL SAMPLING EQUIPMENT AND PROCEDURES

A. GROUNDWATER QUALITY SAMPLING (SUBTASKS 4.2, 4.6 AND TASK 5)

1. Objective

The objective of this activity is to collect groundwater quality samples representative of the screened interval of the well.

2. Personnel and Responsibilities

Sampling teams - Two teams of two people each will be responsible for purging wells, collecting water quality samples, providing site safety during sampling, decontamination of equipment and proper disposal of all purged water.

Chain-of-Custody Technician - This person will be responsible for all chain-of-custody records, preparing all sample bottles for the sampling teams, packaging and shipping samples with assistance from the sampling team members. This person will also assist the analytical technician in sample filtering, preserving and pH and conductivity measurements particularly in Subtask 4.2.

Analytical Technician - This person will be responsible for conducting the on-site volatile organic analyses (Subtask 4.2 only), filtering, preserving, conducting the pH and conductivity measurements and assisting in sample preparation particularly in Tasks 4.6 and 5.

3. Methods - Monitoring Wells

Water Levels - A water level will be obtained using a weighted tape and sounding device or an electric water level meter, measuring to the nearest ± 0.01 ft. If a floating oil layer is suspected to be present, based on drilling or previous sampling observations, an oil water interface probe will be used to measure the depth to fluid and depth to water.

Purging

1. If floating product is observed, a stainless steel bailer will be used to collect the sample of the floating product without purging. The stainless steel bailer will then be used to purge the well of three volumes and to collect required samples (See Table 6 of the QAPP for required bottles, preservatives and handling).

2. At all wells where floating product is not present, a Johnson Keck sampling pump with packer will be used to purge and collect the samples.

3. The pump will be set within the screened interval and a packer will be inflated above the pump within the stainless steel riser section above the screen.

4. The pump will be run to remove a minimum of three volumes of the isolated zone of the well. Volume to be removed is calculated by 3 times 0.16 gallons/ft of 2-inch well times the length of the isolated zone.

5. Water levels above the isolated zone will be monitored regularly to determine whether any leakage past the packer is occurring. If more than 10% of the purged volume comes from leakage past the packer (0.3 times length of isolated interval) the packer will be deflated and the entire volume of the well purged.

6. Purge water discharge will be collected in a tank.

7. When the purged water tank is full, it will be discharged to the city sewer at a point directed by the MDNR.

Sample Collection

1. Samples will be collected directly from the sampling pump discharge using the bottles listed in Table 6 of the QAPP.

2. All sample bottles will be labeled with the time of sample collection in addition to the other chain-of-custody items prepared by the chain-of-custody technician.

3. Samples collected from the bailer (those wells with floating product observed) will be collected with a minimum amount of water disturbance.

QC Samples

QC samples will be collected at the following rate:

- 1 duplicate/10 samples or 1/day, whichever is less.
- 1 sample blank/10 samples, sample blanks will be collected by using the sampling device (the pump or bailer) and collecting a sample immediately after decontamination.
- 1 trip blank/20 samples
- 1 one matrix spike/20 samples

Sample Handling Preparation and Sample Analysis

- All samples will be iced immediately after collection

- Filtering will be conducted through a 0.45 um pressure filtration device as soon as practible after sample collection

- Preservation will be conducted as specified in Table 6 of the QAPP.

- pH and conductivity will be measured as specified in Appendices C1 through C4 of the QAPP.

Decontamination

- Decontamination will be conducted by washing in TSP solution using city water, followed by two rinses with distilled water.

- The pump and discharge tubing will be immersed in the wash water and pump a minimum of two volumes of water. The pump will be moved to the first rinse and water pumped into the wash tank until the TSP is substantially removed from the pump and discharge hose. The second rinse will follow a similar procedure.

- Bailer used to sample oily groundwater will be decontaminated by rinsing with acetone followed by the same wash sequence detailed above.

Sample Shipment

Following sample collection, the sample bottles will be decontaminated in the Contamination Reduction Zone. The Sampling Team Member and/or Sampling Team Leader will help the chain-of-custody technician prepare documentation and package the bottles for shipment. Bottles will be labeled with all required information and this information recorded in the field notebook. Sample bottles will be placed into sealed clear plastic bags with the sample tags visible. Samples will be placed in coolers (maintained at about 4°C) for storage and shipment. Ice will be sealed in plastic bags to prevent leakage. The bottles will be cushioned using plastic form or other similar packing material. Specific shipping requirements are outlined in Table 6 of the QAPP.

B. SOIL GAS SAMPLING AND ANALYSIS (SUBTASK 4.3)

1. Objective

To collect samples of near-surface soil gas for analysis at the on-site GC. Results of the analyses will be used to continually re-evaluate possible sampling locations and to be used for evaluating monitoring well locations.

2. Personnel and Responsibilities

Sampling Team - Two-person sampling team to drive the sampling probe and collect the soil gas sample for analysis.

Laboratory Technician - Will be responsible for GC analysis of the soil gas samples.

3. Methods

Sample Collection

- The steel sampling probe will be driven into the ground to a depth of a minimum of 2.5 ft.

- The drive head will be removed from the probe and the sampling head attached with teflon tubing connected to the sample bottle in line with the pump upstream of the sample bottle. Sample bottle will be a 250 ml bottle with a septum and 2 stop cocks. The probe and tubing will be purged to remove a minimum of one volume of air from the probe, tubing and sample bottle, not exceeding 20 centibars of vaccuum.

- Sample will be collected following purging by closing the stop cocks on the sample bottle. The sample will be immediately wrapped in aluminum foil and put in a dark area. The samples will not be cooled so as not to cause condensation of moisture within the sample bottle.

Decontamination

- The sample probe and sampling tubes will be decontaminated by drawing a minimum of 10 volumes of ambient air through the probe and tubing. If ambient air results in contaminated blanks, decontamination will be completed using the GC carrier gas.

- Sample bottles will be decontaminated by flushing a minimum of 10 volumes of high purity air from the GC.

Sample Analysis

Sample analysis and QC will be conducted as described in the QAPP (Appendix G).

C. WELL DRILLING (SUBTASK 4.4 AND 5)

1. Objective

Eighteen wells for a total of 1,800 feet of drilling and well installation are planned for the Phase I investigation. Of this total, 11 wells at 7 locations are planned for determining groundwater flow directions and water quality sampling during drilling. The 7 remaining wells will be located based on the results of the soil gas sampling program, preliminary testing of existing wells, analysis of water samples collected during drilling and geophysical logging. The ultimate objective is to install wells in locations to obtain representative samples that characterize the contaminant plume(s).

2. Personnel and Responsibilities

Team Leader - The team leader will coordinate the three drilling rigs, soil gas sampling and analytical work. This person will interpret results of the soil gas and water quality analyses and will make decisions in cooperation with the project manager and MDNR on the depth of the screened interval and locations for future drilling sites.

Site Geologist/Geotechnical Engineer - A geologist or geotechnical engineer will be assigned to each individual drilling rig working on the site to collect and classify soil samples, water quality samples, to prepare boring logs and well details, document the methods used for well construction and development and provide site safety monitoring for the drilling operation in Level D protection.

Site Safety Officer - The site safety officer will be responsible for coordinating site safety activities on each of the three drilling rigs and other concurrent operations (soil gas sampling) and providing assistance on any sampling activity where Level B or C work would be on-going. The site safety officer will also advise the team leader as to the sequencing of activities to avoid the need for more than one activity taking place in Level B or C protection.

3. Methods

Drilling - Shallow borings will be drilled using 4 1/4-inch ID hollow-stem augers with a screened lead auger. The well will be drilled to a depth of 10 ft below the water table. If a water head is needed to eliminate sand moving up into the augers, city water can be added to the augers. If city water is used, the daily VOC analysis of the city water will be completed using the on-site GC.

Deep borings will be drilled using 6 1/4-inch ID hollow-stem augers with a lead screened auger. The drilling procedure will be as follows:

- Drill the hollow-stem augers to a depth of 60 ft or 5 ft into the semi-confining layer if present.

- Remove the hollow-stem augers.

- Wash bore 6 inch casing to the final depth drilled with the hollow-stem augers.

- Pull back casing, approximately 1 ft.

- Place approximately 2 ft of bentonite pellets into the hole and advance casing into the bentonite and natural clay material to provide a seal.

- The boring will be advanced using clear water rotary drilling while advancing 5 inch casing below the 6-inch casing.

- If necessary, 4-inch casing will be telescoped within the 5-inch casing and advancing the 4-inch casing to the total depth of boring.

Soil Sampling - Soil sampling will be conducted according to ASTM D1586 using a 2-inch split-spoon sampler. Samples will be collected at a 5-ft interval to a depth of 25 ft, and 10-ft intervals to the bottom of the borehole or at changes in soil type.

Water Quality Sampling and Analysis - Water quality samples will be collected on the following interval from the initial 18 wells listed in Table 3 of the QAPP:

- one sample between the water table and 60 ft;
- from any coarse-grained unit within the clay zone;
- One sample per 10-ft interval below 60 ft or the base of the clay, whichever is lower.

Sampling zone isolation - the sampling zone will be isolated by either driving a 2-inch, 3-ft long galvanized well point into the sand or by setting a packer within the bottom of the casing and sampling from the riser pipe.

The riser pipe will be purged of three well volumes using a Brainard Kilman 1.7 pump.

One 120 ml VOA vial will be collected, two for on-site GC analysis and two for CLP GC/MC analysis. All samples will be collected with no head space. Samples will be analyzed on-site according to methods in Appendix G of the QAPP.

Geophysical Logging - Geophysical logging will be conducted in the deep borehole after completion of the boring. A natural gamma log will be run by the site geologist using a constant logging speed of not more than 1/2 crank/second on the Mount Sopris 1000 C logging unit on the 4:1 drive shaft (less than 0.25 ft/second). The geophysical logger will be calibrated as described in Appendix F of the QAPP.

Well Installation - The wells will be installed as shown on Figures 4 and 5 of the QAPP. All joints will be sealed with teflon tape. The site geologist will measure total depth of the hole prior to installation of the well materials and will measure the depth to the top of each material placed prior to placing the next layer.

The bentonite slurry will be placed using a tremie pipe maintaining the tremie pipe below the top of the bentonite slurry.

Development - Each well will be developed using either air lift pumping or pumping with the Brainard Kilman pump until the water is visually clear and on-site pH and conductivity measurements have stabilized or a maximum of 10 well volumes (0.16 gal/ft of water column in the well).

Decontamination - The split spoon sampling device will be decontaminated using a TSP wash followed by two distilled water rinses between each sample.

The drill rig tools will be steam cleaned immediately after each boring, except where a deep boring is conducted with the same rig immediately after completion of an adjacent shallow well.

The Brainard Kilman pump will be decontaminated following each water quality sample using either a TSP wash and clear water rinse or steam. If water quality results from the on-site lab indicate all compounds of concern are below detection prior to the next sample, no decontamination will be necessary.

Waste Disposal - Cuttings from the drilling operation will be contained only if they are found to be contaminated by screening with a PID or OVA. If on-site disposal of cuttings will create aesthetic problems, they will be removed and disposed of off-site. The off-site disposal area will be coordinated between the city, the MDNR and the team leader.

All drillig fluids, purge water from water quality sampling and well development water will be contained and disposed of to the city sewer at a location and method agreed upon by the MDNR and the City.

SURFACE WATER AND SEDIMENT SAMPLING

Objective

Collect eight surface water and eight sediment samples from surface water locations within the City.

Personnel and Responsibilities

Sampling Team - One team of two people will collect surface water and sediment samples and provide their own site safety monitoring.

Chain-of-Custody Technician - This person will prepare all sample labels and provide chain-of-custody records and package and ship samples.

Methods

Surface Water Sampling - Surface water samples will be collected prior to sediment samples at eight locations.

Surface water samples will be collected using stainless steel sampling equipment. Sampling equipment will be decontaminated using TSP wash and double clear water rinse. Sample bottles will be as listed in Table 6 of the QAPP.

Surface water samples will be analyzed for pH and conductivity using the methods in Appendices C1 through C4 of the QAPP.

Sediment Sampling - Sediment samples will be collected following surface water samples using a hand-corer. The hand-core will be driven to a depth of 6 inches and splits of the material will be collected in the sample bottles listed in Table 6 of the QAPP. The VOA sample will be collected as soon as possible after sample removal. The hand-core will be decontaminated in the same manner as the surface water sampling equipment.

HYDRAULIC CONDUCTIVITY TESTS

Objective

The hydraulic conductivity tests are intended to obtain an estimate of the hydraulic conductivity of the screened interval of the well tested.

Personnel and Responsibilities

Site hydrogeologist will conduct the test.

Methods

The test methods will follow the procedures outlined in Appendix E of the QAPP. Specifically, this will include the following steps:

- Water level measurement with a tape and sounding device.
- Place the pressure transducer into the well and allow approximately three minutes for the probe to equilibrate to the water temperature and pressure.
- Install the well head device to seal the well head (for piezometers only).
- Enter the reference water level into the data logger and check the water level using the pressure transducer to be sure water level reading is stable.
- After a stabilized water level reading is obtained from the pressure transducer, the well will be pressurized with sufficient air pressure to displace 10 ft of water (0.4 PSI/ft of water) (for piezometers only).
- Air pressure will be maintained until the water level reading from the transducer is constant (for piezometers only).
- The air pressure will then be instantaneously released while running the pressure transducer recorder in the log sampling mode (for piezometers only).

- At water table wells a single bailer will be removed to reduce the water level, while running the pressure transducer recorder in the log sampling mode.
- The test results will then be immediately printed out to obtain a hard copy.
- Data will be transferred at the end of the day to a micro computer.

SAMPLE DOCUMENTATION

Samples shipped to performing laboratories will be handled under chain-of-custody procedures. Standard forms including sample tags, traffic reports, chain-of-custody forms, and custody seals used for sample tracking will be maintained. All pertinent information regarding the samples will be recorded in the site log book maintained by the team leader and in logs maintained by each sampling crew. The information will include sampling time, location, tag numbers, designation and samplers. Pertinent PID readings, weather conditions, and field modifications of sampling strategy will be recorded. The log book will be maintained in indelible ink and will be in a bound volume unless weather conditions dictate otherwise. Photographs with the time, data and location noted in the photo will be taken at each sampling location. Sample documentation for analyses by field GC will be limited to labels and logbook entries by sampling crew and field analyst.

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SGW/sss/MJR
[sss-600-50a]

C

APPENDIX C-1

FIELD MEASUREMENT OF pH

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: EPA 1983, p. 150.1

Sensitivity: 0.01 pH unit

Optimum Range: pH 1.00 to 12.00

Sample Handling: Determine on-site, if possible

Reagents and Apparatus:

1. pH meter (Orion 901 or 407A for lab use, Orion 211, 221, and 230 for field use).
2. Combination pH electrode.
3. Magnetic stirrer and stir bars (for lab use).
4. Beakers or plastic cups.
5. pH buffer solutions, pH 4.00, 7.00, and 10.00.
6. Deionized water in squirt bottle.

Calibration:

1. Place combination electrode in pH 7.00 buffer solution.
2. After allowing several minutes for meter to stabilize, turn calibration dial until reading of 7.00 is obtained.
3. Rinse electrode with deionized water and place in pH 4.00 or pH 10.00 buffer solution. Use pH 7.00 and 4.00 for samples with pH <8, and buffers 7.00 and 10.00 for samples with pH >8.
4. Wait several minutes and then turn slope adjustment dial until reading of 4.00 or 10.00 is obtained.
5. Rinse electrode with deionized water and place in pH 7.00 buffer. If meter reading is not 7.00, follow Steps 2-5 again.

Procedure:

1. Calibrate meter using calibration procedure.
2. Pour the sample into clean beaker or plastic cup.

3. Place stir bar in beaker and put on magnetic stirrer (low speed) for lab measurement of pH. Swirl cup gently for field measurement of pH.

4. Check temperature of sample. It should be $\pm$ 2°C of the buffer solutions.

5. Rinse electrode with deionized water.

6. Immerse electrode in sample. The white KCl junction on side or bottom of electrode must be fully immersed in solution. Allow sufficient time for reading to stabilize. Record pH. Rinse electrode with deionized water.

7. Recheck calibration with pH 7.00 buffer solution after every 20 samples and at the end of the analytical run.

Quality Control:

1. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates should be $\pm$ 0.2 pH units. Average the results.

2. All glassware is to be soap and water washed, tap rinsed and deionized water rinsed prior to analyses.

Notes:

1. The pH test is temperature dependent. Therefore, temperatures of buffers and samples should be within 2°C of each other. For refrigerated or cool samples, use refrigerated buffers to calibrate meter.

2. Interferences in pH measurements occur with presence of weak organic and inorganic salts, and oil and grease. If oil and grease are visible, note on data sheet. Clean electrode with soap and water, followed by 10% HCl and deionized water. Then recalibrate meter before analysis of next sample.

3. Electrode should be stored in pH 4.00 buffer.

4. Before leaving laboratory for field work:

   a. Check batteries.
   b. Do quick calibration at pH 7.00 and 4.00 to check electrode response and batteries.
   c. Obtain fresh pH buffer solutions.

5. Following field measurements:

   a. Report any problems with meter or electrode.
   b. Clean meter and meter case.
   c. Make sure electrode is stored in pH 4.00 buffer.

Approved 7/22/86

Michael Linskens

Michael J. Linskens
Laboratory Manager

[ALM-1-26]

APPENDIX C-2

INSTRUCTION MANUAL ORION MODEL 211
pH METER

INSTRUCTION MANUAL
model 211
digital pH meter

ORION RESEARCH

contents

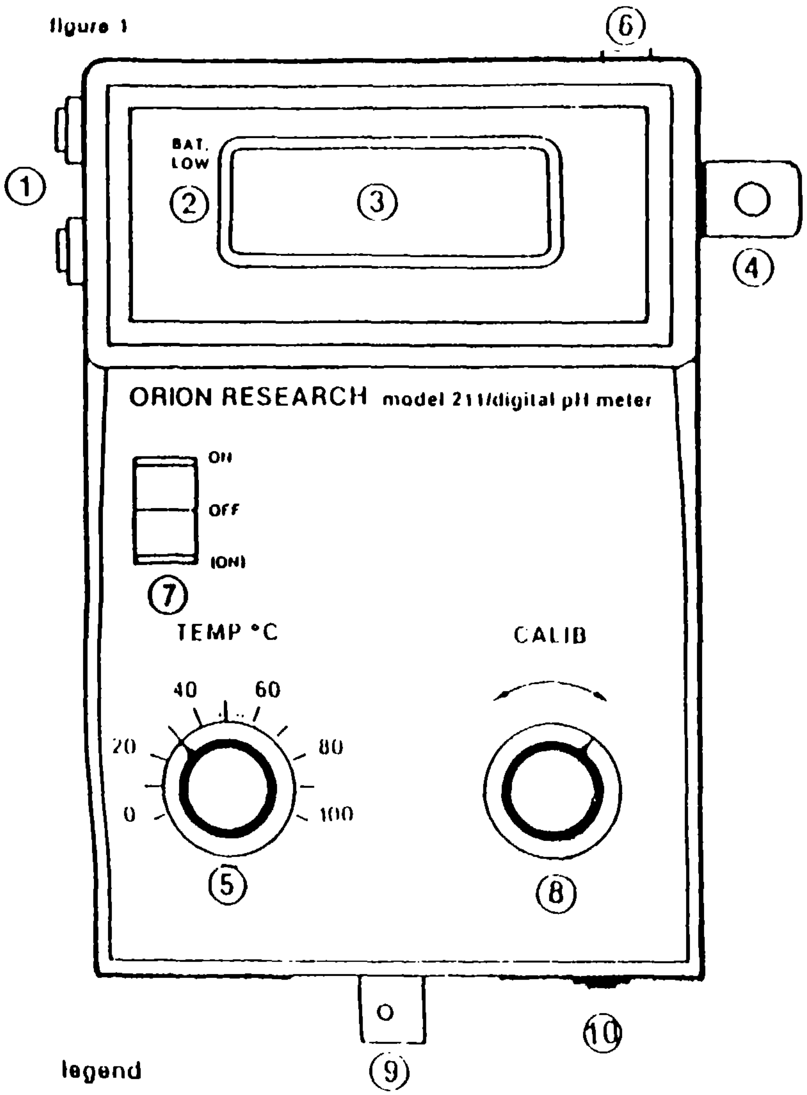
repair/service

For information on repair or replacement of this instrument, contact Orion Research toll-free. Ask for Customer Service.

ORION RESEARCH INCORPORATED
Customer Service
840 Memorial Drive
Cambridge, Massachusetts 02139 U.S.A.
800-225-1480 (Continental U.S.)
617-864-5400 (Massachusetts, Alaska, Hawaii, Canada)
Telex: 921466

Form IM211/3860
Printed in U.S.A.

figure 1



legend

1 strip chart recorder binding posts
2 BAT LOW
3. LC display
4. support rod clip
5. temperature indicator control
6 AC line adapter input
7 function control
8 calibration control
9 electrode connector
10 slope control

introduction

The Model 211 is a battery- or line-operated (110/220 V AC adapter) digital pH meter for field or laboratory use. The meter is complete with strip chart recorder binding posts and is supplied with an unbreakable, gel-filled combination pH electrode, one packet of pH 7 buffer powder, one bottle for pH 7 buffer, one bottle for distilled water, support rod, electrode holder, AC adapter, six 1.5 V batteries, shorting plug, and carrying case.

instrument description

See figure 1.

1. **strip chart recorder binding posts:** black post is low (ground) and red post is high input side of recorder. See page 8.
2. **BAT LOW:** an arrow pointing towards BAT LOW appears on the display when battery requires replacement.
3. **LC display:** pH display over the range of 0 - 14 with ± .01 pH units resolution.
4. **support rod clip:** holds steel rod used to mount electrode holder.
5. **temperature indicator control (TEMP °C):** compensates for variation in electrode slope or temperature changes. Used in two buffer calibration.
6. **AC line adapter input:** jack used to insert AC line adapter. With AC line adapter operational, the internal battery is bypassed.
7. **function control:** rocker switch with three positions - ON, OFF and (ON). Depress (ON) for a momentary reading. The switch will return to OFF when released.
8. **calibration control (CALIB):** used to calibrate the meter with buffers of known pH.
9. **electrode connector:** accepts BNC connector from pH electrode.
10. **slope control:** screwdriver adjustment used to set second buffer in two buffer calibration.

instrument set-up

support rod

1. Insert steel support rod into the hole in the support rod clip on side of the meter.
2. Mount electrode holder on the rod by pinching to compress the spring. Release to hold in place.

power source

The Model 211 operates on six nonrechargeable 1.5 volt batteries or on 110 or 220 ± 20% V with an approved AC adapter (specify voltage when ordering). Low battery is indicated by the BAT LOW indicator on the display.

NOTE: Batteries are not rechargeable - use of line adapter whenever possible will prevent the unit's batteries from being discharged. If battery operation is desired, follow installation instructions under battery replacement.

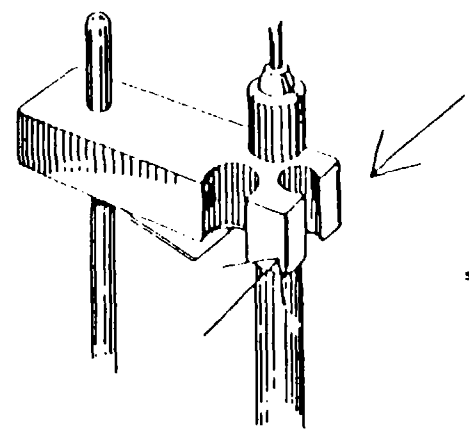
meter check-out

1. Install six AA batteries in the meter. Orient the (+) and (-) battery terminals to match the orientation shown in the battery compartment.
2. Depress ON button on the front panel. If the BAT LOW indicator on the front display lights up, the batteries must be replaced.
3. If battery mode is not to be used, disregard steps 1 and 2. Insert pin end of appropriate AC line adapter into the meter, and the other end into the appropriate grounded AC line receptacle.
4. Attach BNC shorting plug to BNC input on the bottom side of the meter. Depress ON button on the front panel. Turn CALIB knob so display reads a steady 7.00. If this cannot be done consult ORION Technical Service.
5. Remove the shorting plug. Successful completion of steps 1-4 show the [illegible]t is ready for use.

connecting electrode

1. Insert the BNC connector into the electrode jack on the bottom panel of the meter. Turn connector clockwise until it seats firmly.
2. Mount electrode in the electrode holder by spreading the electrode clip open and sliding the electrode into the holder so that the clip closes on electrode cap. See **figure 2**.
3. Follow **measurement procedures** to use the meter to measure pH.
4. Disconnect electrode by turning connector counterclockwise until released from pin.

figure 2



squeeze as shown to insert electrode

measurement procedures

general measurement technique

temperature: All samples and buffers should be at the same temperature, as small variations in temperature can cause errors in measurement. The slope of the pH electrode, the potential of the reference electrode, and the pH of the buffer are temperature dependent.

cleaning electrodes: Electrode should be rinsed and shaken between measurements to remove drops and to prevent solution carryover.

stirring: Stir measured solutions moderately to obtain good contact between the glass bulb and the solution. Insert electrode to a depth of about 3 cm.

pH measurements

single-buffer standardization
(where maximum precision is not required)

NOTE: For maximum accuracy it is recommended that a two-buffer calibration be performed once at the beginning of each day (see page 7). This procedure ensures the correct setting of the slope control. Subsequent measurements during the day may be made using a single point calibration.

1. Place the electrode in a buffer solution whose pH is near the expected pH of the sample. Insert electrode to a depth of about 3 cm and stir moderately.
2. Set the **temperature indicator** control to the temperature of the buffer.
3. Set the **function control** to ON and allow the buffer reading to stabilize. Adjust the **CALIB** so that the display indicates the pH of the buffer at the solution temperature. See **Table 1**.
4. Remove the electrode from the buffer solution and rinse by stirring moderately in distilled water. Shake off excess drops of water.
5. Place electrode in the sample to a depth of about 3 cm and stir moderately. Set the **function control** to ON and allow the reading to stabilize. Record the steady pH reading.

two-buffer standardization
(where maximum precision is required)

1. Select two buffers to bracket the expected pH of the sample, with one buffer having a pH of 7.
2. Place the electrode in the pH 7 buffer to a depth of about 3 cm and stir moderately. Set the **temperature indicator control** to the temperature of the buffer. Set the **function control** to ON and allow the reading to stabilize. Turn **CALIB** until the display indicates the pH of the buffer at the solution temperature. See **table 1**.
3. Remove electrode from the first buffer and rinse by stirring moderately in distilled water. Shake off excess drops of water.
4. Place the electrode in the second buffer to a depth of about 3 cm and stir moderately. Set the **function control** to ON and adjust the **slope control** until the pH at the solution temperature is displayed. See **Table 1**.
5. Remove the electrode and rinse by stirring moderately in distilled water. Shake off excess drops of water.
6. **Place the electrode in the sample to a depth of about 3 cm and stir moderately. Set the function control to ON and allow the reading to stabilize. Record the steady pH reading.**

TABLE 1

TEMP (°C)	pH 7.00 Buffer	pH 4.01 Buffer	pH 10.01 Buffer
5	7.08	4.00	10.25
10	7.06	4.00	10.18
15	7.03	4.00	10.12
20	7.01	4.00	10.06
25	7.00	4.01	10.01
30	6.98	4.02	9.97
35	6.98	4.02	9.93
40	6.97	4.03	9.80
50	6.97	4.06	9.83
60	6.98	4.09	--

battery replacement

To replace the batteries, remove the panel on the back of the meter. Be sure to observe the polarity marking when inserting new batteries.

recorder output

The red and black binding posts at the side of the meter provide an output for strip chart recording of absolute mV independent of function mode. For recorders with input impedance of 100 Kilohms or greater, the output is fixed to about 100 mV/pH. pH 14.00 output is 1.40 V. Lower impedance recorders may be used but full-scale output is reduced.

1. Connect the lead from the high (input side of the recorder) to the red binding post and the lead from the low (ground) side to the black binding post.
2. Proceed according to directions in the strip chart recorder instruction manual.

repair and service

ORION warranty covers failures due to manufacturer's workmanship or material defect from the date of purchase by the user. User should return the warranty card to ORION and retain proof of purchase. Warranty is void if product has been abused, misused, or repairs attempted by unauthorized persons.

Warranties herein are for products sold/installed for use only in the United States and Canada. For ORION products purchased for use in all other countries consult local in country, authorized ORION sales agent/distributor for product warranty information.

A Return Authorization Number must be obtained from ORION Laboratory Products Customer Service before returning any product for in warranty repair, replacement or credit.

"No Lemon" Instrument Warranty

The instrument is covered by the ORION "No Lemon" warranty. If the instrument fails within twelve months from date of purchase for any reason other than abuse, the purchaser may elect to have it repaired or replaced at no charge. This warranty covers the original or replacement/repaired meter from date of original meter purchase, the warranty is not extended beyond the buyer's original warranty date.

accessories

815600	Ross™ epoxy body, bulb guard combination pH electrode
9104BN	Laboratory grade combination pH electrode (BNC connector)
910600	GX series epoxy body, gel-filled combination electrode (BNC connector)
912600	GX-series epoxy body, gel filled flask combination electrode (BNC connector)
913600	GX series epoxy body, gel-filled flat surface combination pH electrode (BNC connector)
915600	RX-series refillable, epoxy body combination pH electrode (BNC connector)
9162BN	Combination pH electrode with rugged bulb (BNC connector)
9163BN	Combination pH electrode with needle shape (BNC connector)
910004	pH 4 buffer packets, box of 25 packets, each packet making 200 ml of buffer
910007	pH 7 buffer packets, box of 25 packets, each packet making 200 ml of buffer
910009	pH 9 buffer packets, box of 25 packets, each packet making 200 ml of buffer
910104	pH 4.01 buffer, 475 ml bottle
910107	pH 7.00 buffer, 475 ml bottle
910110	pH 10.01 buffer, 475 ml bottle
970899	Dissolved oxygen electrode
910002	Electrode holder
020030	Shorting plug
020120	110V AC line adapter
020121	220V AC line adapter

specifications

package contents	model 211 digital pH meter, with model 910600 gel filled unbreakable combination pH electrode, support rod, electrode holder, bottles for pH 7 buffer and distilled water, one packet pH 7 buffer powder, AC adapter, six 1.5 V batteries, and carrying case
range	0 to 14 pH
resolution	± .01 pH
temperature compensation	manual (0 to 100°C)
isopotential point	pH 7 (fixed)
power requirement	six 1.5 V batteries; **battery life:** 3000 ten second intermittent measurements when line adapter is not used. **line adapter:** 110 or 220 V ± 20%, 50/60 Hz
dimensions	14 cm high x 9 cm wide x 4.5 cm deep
weight	0.4 kg

specifications subject to change without notice

notice of compliance

The Model 211 may generate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If the Model 211 does cause interference to radio or television reception, which can be determined by turning the unit off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- reorient the receiving antenna
- relocate the Model 211 with respect to the receiver
- move the Model 211 away from the receiver
- plug the Model 211 into a different outlet so that the meter and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful:

"How to Identify and Resolve Radio-TV Interference Problems"

This booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock No. 004-000-00345-4.

APPENDIX C-3

FIELD MEASUREMENT OF SPECIFIC CONDUCTANCE AND TEMPERATURE

CONDUCTIVITY
(YSI METER)

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Specific Conductance (Electrical Conductivity), umhos/cm @ 25°C

Reference: EPA 1983, p. 120.1.

Detection Limit: 1 umhos/cm @ 25°C

Sample Handling: Determine on-site

Reagents and Apparatus:

1. Conductivity meter, YSI 33 SCT
2. Deionized water
3. Conductivity standard, 1413 umhos/cm @ 25°C.

Procedure:

1. With mode switch of meter in off position, check zero setting. If not zeroed, use meter adjusting screw to zero.

2. Plug probe into jack located on side of meter.

3. Turn mode switch to red line, and turn red line knob until needle aligns with red line on dial. Change batteries if meter cannot be aligned.

4. Analyse the conductivity standard. If the result is within the specified control ranges, analyse samples. A control should be analysed after every 20 samples and at the end of every analytical run.

5. Totally immerse and suspend the probe in the water sample. Do not allow probe to touch the sides of the sample container.

6. Turn mode switch to appropriate conductivity scale, X100, X10, or X1. Use scale that produces a mid-range output on meter.

7. Wait for needle to stabilize (about 15 seconds) and record conductivity as indicated. Multiply reading by scale setting.

8. While gently agitating probe, take sample temperature (°C) to nearest 1°C and record.

9. Rinse probe with deionized water.

10. Record specific conductivity and temperature.

Quality Control:

1. A quality control check standard of 1413 umhos/cm is to be analyzed before and after every 10 samples. The check standard must be within the critical levels or the samples run prior to the last check standard are to be reanalyzed. Before the samples are reanalayzed, the analyst must diagnose the problem and consult with the laboratory supervisor until the problem has been resolved and approved. Record the result of the check standard in the quality control check standard book.

2. Duplicate 1 out of 10 samples. If less than 10 samples are analyzed, a duplicate is still required. Duplicates should be within 95%. Average the results.

3. All glassware is to be soap and water washed, tap rinsed and deionized rinsed prior to analysis.

Notes:

1. Calculate specific conductivity at 25°C using following formula:

$$G_{25} = \frac{G_T}{[1 + 0.02\ (T-25)]}$$

G_{25} = Specific conductivity at 25°C, umhos/cm

T = Temperature of sample, °C

G_T = Conductivity of sample at temperature T, umhos/cm

2. Analyze and record the conductivity standard solution (1413 umhos/cm @ 25°C) with each data set.

3. Record on field sheet which meter and probe were used. The meter should be wiped clean as necessary.

Reagent Preparation:

1. Conductivity Standard: Dissolve 0.7456g anhydrous KCl in deionized water and dilute to 1000 mL at 25°C in a volumetric flask. Specific conductance is 1413 umhos/cm at 25°C.

approved 9/6/86

Michael Linskens

Michael J. Linskens
Laboratory Manager

[AL-1-20]

APPENDIX C-4

OPERATING INSTRUCTIONS YSI MODEL 33 CONDUCTIVITY METER

TABLE OF CONTENTS

GENERAL DESCRIPTION

The YSI Model 33 and 33M S.C.T. Meters are portable, battery powered, transistorized instruments designed to accurately measure salinity, conductivity and temperature. They use a probe consisting of a rugged plastic conductivity cell and a precision YSI thermistor temperature sensor combined in a single unit.

Conductivity with the Model 33 is expressed as micromhos/centimeter (µmhos/cm); with the 33M, it's millisiemens/meter (mS/m). These are measurements of the electrical conductance the sample would show if measured between opposite faces of a 1cm cube. (Conversion information: 1 µmho/cm = 0.1 mS/m.) Salinity is the number of grams of salt/kilogram of sample (‰ = parts per thousand). This measurement assumes the sample contains a "standard" sea water salt mixture. The sample temperature is measured in degrees Celsius.

Salinity measurements are manually temperature compensated by direct dial. Conductivity measurements are not temperature compensated; however, a temperature function is provided on the instrument to aid with calculation of corrections. Also, when just temperature and conductivity are known, it is possible to calculate salinity, and when only temperature and salinity are known, it is possible to calculate conductivity.

SPECIFICATIONS

Model 33 Conductivity

Ranges	0–500, 0–5,000, 0–50,000 µmhos/cm with YSI 3300 Series Probes (Note: The µmho designations on the meter are a shorthand form for "µmho/cm".)
Accuracy	±2.5% max. error at 500, 5,000 and 50,000 plus probe ±3.0% max. error at 250, 2,500 and 25,000 plus probe See Error Section

Readability	2.5 µmhos/cm on 500 µmho/cm range 25 µmhos/cm on 5,000 µmho/cm range 250 µmhos/cm on 50,000 µmho/cm range
Temperature Compensation	None

Model 33M Conductivity

Ranges	0–50, 0–500, 0–5,000 mS/m with YSI 3300 Series Probes
Accuracy	±2.5% max. error at 50, 500 and 5,000 plus probe ±3.0% max. error at 25, 250 and 2,500 plus probe See Error Section
Readability	0.25 mS/m on 50 mS/m range 2.5 mS/m on 500 mS/m range 25.0 mS/m on 5,000 mS/m range
Temperature Compensation	None

Salinity

Range	0–40‰ in temperature range of −2 to +45°C
Accuracy	Above 4°C: ±0.9‰ at 40‰ and ±0.7‰ at 20‰ plus conductivity probe Below 4°C: ±1.1‰ at 40‰ and ±0.9‰ at 20‰ plus conductivity probe See Error Section
Readability	0.2‰ on 0–40‰ range
Temperature Compensation	Manual by direct dial from −2 to +45°C

Temperature	
Range	−2 to +50°C
Accuracy	±0.1°C at −2°C ±0.6°C at 45°C plus probe. See Error Section
Readability	±0.15°C at −2°C to ±0.37°C at 45°C
Power Supply	Two D size alkaline batteries. Eveready E95 or equivalent provide approximately 200 hrs. of operation
Probe	YSI 3300 Series Conductivity/Temperature Probe. Nominal Probe Constant K = 5/cm
Accuracy	±2% of reading for conductivity and salinity. Error of ±0.1°C at 0°C and ±0.3°C at 40°C
Instrument	
Ambient Range	Satisfactory operation −5 to +45°C. A maximum error of ±0.1% of the reading per °C change in instrument temperature can occur. This error is negligible if the instrument is readjusted to redline for each reading.

OPERATION PROCEDURE

1. **Setup**
   (a) Adjust meter zero (if necessary) by turning the bakelite screw on the meter face so that the meter needle coincides with the zero on the conductivity scale.
   (b) Calibrate the meter by turning the MODE control to REDLINE and adjusting the REDLINE control so the meter

needle lines up with the redline on the meter face. If this cannot be accomplished, replace the batteries.
   (c) Plug the probe into the probe jack on the side of the instrument.
   (d) Put the probe in the solution to be measured. (See Probe Use.)
2. **Temperature**
   Set the MODE control to TEMPERATURE. Read the temperature on the bottom scale of the meter in degrees Celsius. Allow time for the probe temperature to come to equilibrium with that of the water before reading.
3. **Salinity**
   (a) Transfer the temperature reading from Step 2 to the °C scale on the instrument.
   (b) Switch the MODE control to the SALINITY position and read salinity on the red 0-40 ‰ meter range.
   (c) Depress the CELL TEST button. The meter reading should fall less than 2%; if greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.
4. Conductivity on Model 33 (Model 33M data are in parentheses.)
   (a) Switch the MODE control to the X100 scale. If the reading is below 50 on the 0-500 range (5.0 on the 0-50 range), switch to the X10 scale. If the reading is still below 50 (5.0), switch to the X1 scale. Read the meter scale and multiply the reading appropriately. The answer is expressed in μmhos/cm (mS/m). Measurements are not temperature compensated.

Example	Meter Reading	247 (24.7)
	Scale	X10
	Answer	2470 μmhos/cm (247.0 mS/m)

(b) When measuring on the X100 and X10 scales, depress the CELL TEST button. The meter reading should fall less than 2%; if greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.

NOTE: The CELL TEST does not function on the X1 scale.

5. Error

The maximum error in a reading can be calculated by using the graphs in the following sections.

(1) Temperature

The temperature scale is designed to give the minimum salinity error when the temperature readings are used to compensate salinity measurements.

Figure 1 shows total error for probe and instrument versus °C meter reading.

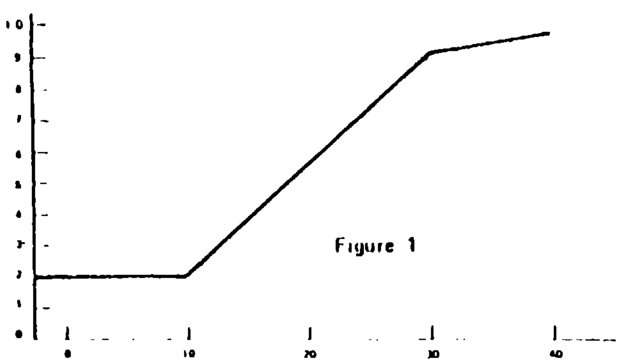


Figure 1

Example:	Meter Reading	15°C
	Total Error	0.4°C
	Accuracy	15°C ± 0.4°C for probe and instrument combined

(2) Conductivity on Model 33 (Model 33M data are in parentheses.)

Figure 2 shows the worst case conductivity error as a function of the conductivity reading for the probe and instrument combined.

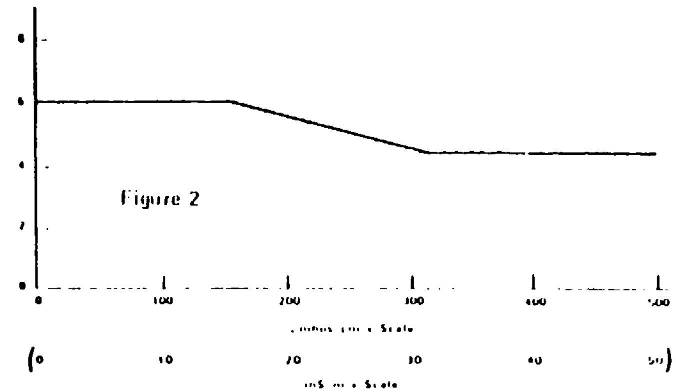


Figure 2

Example	Meter Reading	360 μmhos/cm (36 mS/m)
	Scale	X10
	% Reading Error	± 4.5%
	Accuracy	3600 ± 162 μmhos/cm (360 ± 16.2 mS/m) for probe and instrument

(3) Salinity

The salinity readings are a function of temperature and conductivity, therefore the accuracy is a function of both. The temperature scale and temperature control have been designed to minimize the temperature error contribution to the salinity error. The error shown in Figure 3 is the total of the temperature and conductivity probe, the temperature scale and the salinity scale error.

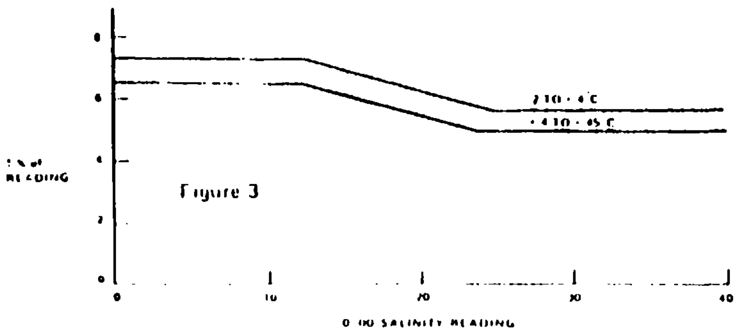
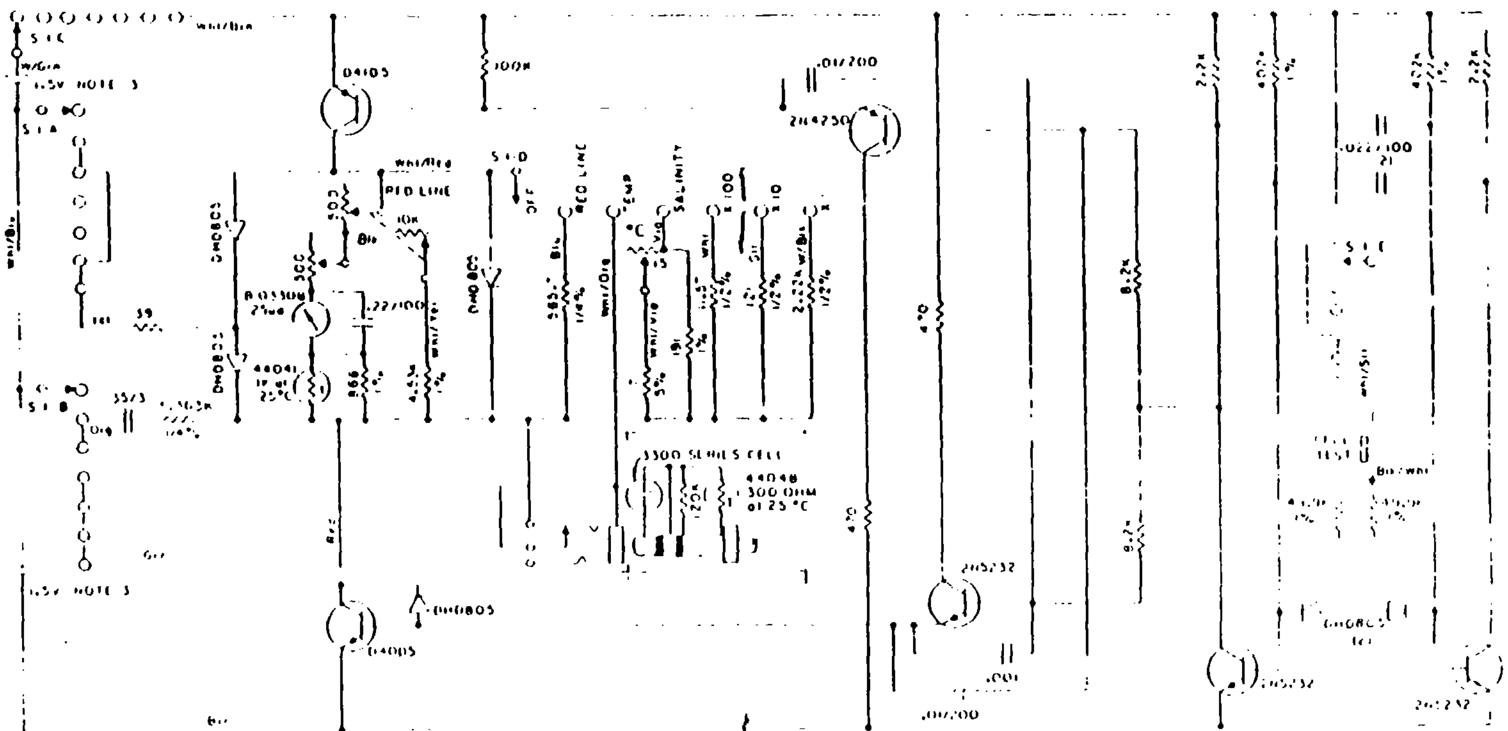


Figure 3

Example	Meter Reading	10 0/00. @ 10°C
	% of Reading Error	6 5%
	Accuracy	10 ‰ ± 0 65 ‰ for all errors, combined worst case



YSI MODEL 33 AND 33M B 03321 E

CIRCUIT DESCRIPTION, MAINTENANCE AND CALIBRATION

1. Description

The circuit is composed of two parts, a multivibrator and switching transistors. The multivibrator produces a square waveform voltage. The square wave is applied to two switching transistors. They alternately apply two batteries of opposite polarity to the probe thus providing AC power which minimizes polarization effects. The meter is in series with one battery and measures the current from it. The current from the battery is proportional to the conductance of the cell. Salinity is measured in a special range conductivity circuit which includes a user adjusted temperature compensator. In the temperature, redline and X1 positions the multivibrator operates at 100 Hz. In the salinity, X100 and X10 positions the multivibrator operates at 600 Hz and in these ranges pushing the CELL TEST button drops the frequency to 100 Hz allowing the operator to judge the degree of probe polarization.

2. Maintenance

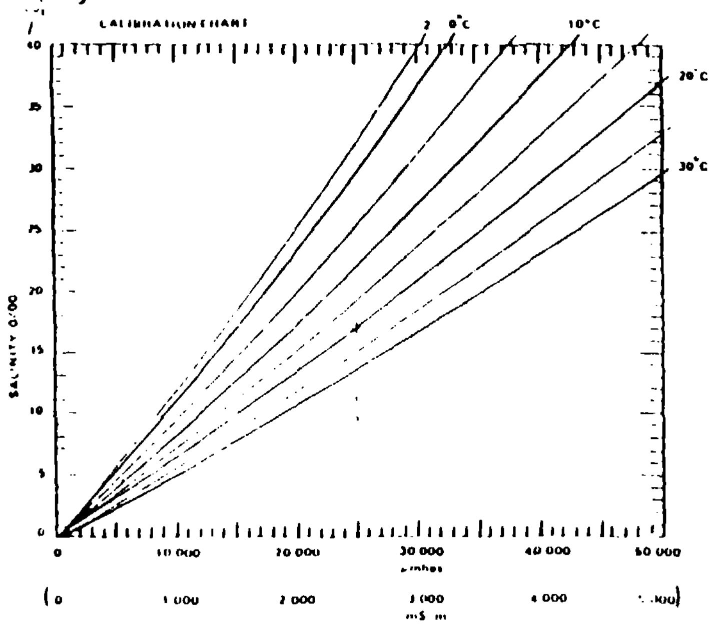
The only maintenance required is battery replacement. Two "D" size alkaline flashlight cells, such as Eveready E95 or equivalent, will provide 200 hrs. of operation. Accuracy will not be maintained if zinc-carbon "D" cells are used. Battery replacement is indicated when the redline adjustment cannot be accomplished.

Replace batteries every six months to reduce the danger of corrosion due to leaky batteries. To replace batteries, remove the six screws from the rear plate. The battery holders are color coded. The Positive (+ button) end must go on red.

3. Calibration of Model 33 (Model 33M data are in parentheses.)

It is possible for the temperature knob to become loose or slip from its normal position. In an emergency the dial can be re-positioned. It must be emphasized that this is an emergency procedure only, and that the instrument should be returned to the factory for proper recalibration at the earliest opportunity.

(a) Read the temperature and conductivity of the solution. Determine the salinity of the solution by running a line vertically on the graph from this conductance value until it intersects the appropriate °C line (interpolate as required for temperature between the given °C lines). From this intersection extend a



line horizontally to the edge of the graph. This determines the salinity for this sample.

Example: 25 000 µmhos/cm and 20°C gives a salinity of 17.
(Example: 2 500 mS/m and 20°C gives a salinity of 17.)

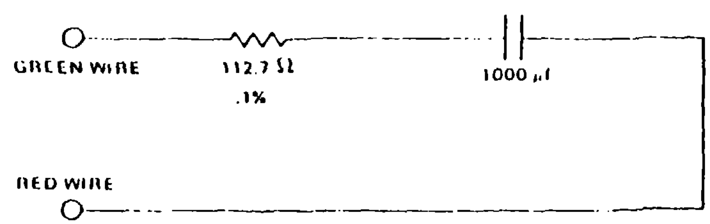
(b) Remove the °C knob, switch to SALINITY and turn the control shaft until the meter needle indicates the salinity value determined in Step (a). In the example given, the value is 17.

(c) Switch to TEMPERATURE. (Note: This temperature reading must be the same as Step (a), if not, begin again at Step (a).) Place the knob on the control shaft (without turning the control shaft) with the knob pointer at the same temperature as the meter reading and tighten both set screws securely.

At earliest opportunity recalibrate using the following procedure or return the instrument to factory for service.

(a) Set the instrument for a salinity measurement as normal.
(b) Substitute a 1000 µf capacitor and 112.7 ohm 0.1% tolerance resistor for the probe.

Connect the resistor and capacitor between the green wire and red wire on the jack connections inside the instrument.



(c) Turn the temperature dial until the meter reads redline

Now install the temperature knob with the arrow at 25°C. This is a *temporary calibration only. Return the instrument to the factory for proper recalibration.*

PROBE

1. Description of YSI 3300 Series Conductivity/Temperature Probe

The YSI 3300 Series Conductivity Probes are designed for field use embodying construction and design for rugged, accurate service.

Each probe features a built in cell constant of 5.0 (500 0/M) ± 2%, a precision YSI thermistor temperature sensor of ± 0.1°C accuracy at 0°C and ± 0.3°C at 40°C and a low capacitance cable assembly terminating in a three therminal 0.25" dia. phone type connector.

The 3310 has a 10 ft. cable and the 3311 is a 50 ft. version. Other lengths are available on special order.

The probe has a rigid P.V.C. body, platinized pure nickel electrodes and a durable cable, providing resistance to a wide range of water borne substances.

2. Maintenance

(a) Cleaning

When the cell test indicates low readings the probable cause is dirty electrodes. Hard water deposits, oils and organic matter are the most likely contaminants.

For convenient normal cleaning soak the electrodes for 5 minutes with a locally available bathroom tile cleaning preparation such as Dow Chemical "Bathroom Cleaner", Horizon Industries "Rally Tile Porcelain and Chrome Cleaner", Johnson Wax "Envy Instant Cleaner", or Lysol Brand "Basin Tub Tile Cleaner".

For stronger cleaning a 5 minute soak in a solution made of 10 parts distilled water, 10 parts isopropyl alcohol and 1 part HCl can be used.

Always rinse the probe after cleaning and before storage.

CAUTION: Do not touch the electrodes inside the probe. Platinum black is soft and can be scraped off.

If cleaning does not restore the probe performance, re-platinizing is required.

(b) Re-Platinizing

Equipment Required —

(1) YSI #3140 Platinizing Solution, 2 fl. oz. (3% platinum chloride dissolved in 0.025% lead acetate solution)

(2) YSI Model 33 or 33M S-C-T Meter

(3) 50 ml glass beaker or equivalent bottle

(4) Distilled water

Procedure —

(1) Clean the probe as in Section (a), either method.

(2) Place the cell in the beaker and add sufficient YSI #3140 solution to cover the electrodes. Do not cover the top of the probe.

(3) Plug the probe into the Model 33 or 33M, switch to the X100 scale to platinize the electrode. Move the probe slightly to obtain the highest meter reading and continue platinizing for the approximate time shown below.

Meter Reading		Time
µmhos/cm	mS/m	(minutes)
30 000	3 000	5
25 000	2 500	6
20 000	2 000	8
15 000	1 500	11
10 000	1 000	16

(4) After the elapsed time remove the probe and rinse in fresh water

(5) Return the solution to its container 2 oz of solution should be sufficient for 50 treatments

3. **Probe Use**

(a) Obstructions near the probe can disturb readings At least two inches of clearance must be allowed from non metallic underwater objects Metallic objects such as piers or weights should be kept at least 6 inches from the probe

(b) Weights are attached to the cable of the YSI 3310 and 3311 Probes The YSI 3327 Weights are supplied in pairs with a total weight of 4 ounces per pair Should it become necessary to add more weight to overcome water currents, we suggest limiting the total weight to two pounds (8 pairs) For weights in excess of two pounds use an independent suspension cable In either case, weights must be kept at least 6 inches away from the probe

(c) Gentle agitation by raising and lowering the probe several times during a measurement insures flow of specimen solution through the probe and improves the time response of the temperature sensor

4 **Cell Calibration & Standard Solutions**

The YSI #3300 Series Cells are calibrated to absolute accuracy of ±1 5% based on a standard solution Since the literature on conductivity does not indicate a consistently accepted standardization method we have chosen the 0 01 demal KCl solution method as determined by Jones and Bradshaw in 1937 as our standard Recent textbooks, as well as the ASTM standards, concur with this choice

The solution is prepared by diluting 0 745 grams of pure dry KCl with distilled water until the solution is 1 kilogram The table below shows the values of conductivity this solution would have if the distilled water were non conductive However since even high purity distilled

water is slightly conductive, the measured conductivity will be higher by an amount equal to the water's conductivity

Temperature °C	Conductivity µmhos/cm	mS/m
15	1141 5	114 2
16	1167 5	116 8
17	1193 6	119 4
18	1219 9	122 0
19	1246 4	124 6
20	1273 0	127 3
21	1299 7	130 0
22	1326 6	132 7
23	1353 6	135 4
24	1380 8	138 1
25	1408 1	140 8
26	1436 5	143 7
27	1463 2	146 3
28	1490 9	149 1
29	1518 7	151 9
30	1546 7	154 7

The operator may use the standard solution and the table to check accuracy of a cell's constant or to determine an unknown constant The formula is shown below

$$K = \frac{R(C_1 + C_2)}{10^6} \quad \text{or} \quad \frac{R(S_1 + S_2)}{10^5}$$

where K = Cell constant
R = Measured resistance in Ω
C_1 = Conductivity in µmhos/cm
C_2 = Conductivity in µmhos/cm of the distilled water used to make solution

S_1 = Conductivity in mS/m
S_2 = Conductivity in mS/m of the distilled water used to make the solution

R, C_1 and C_2, or S_1 and S_2, must either be determined at the same temperature or corrected to the same temperature to make the equation valid.

Note. For further information on conductivity and the above standard information, refer to ASTM Standards Part 23 — Standard Methods of Test for Electrical Conductivity, or Water and Industrial Waste Water — ASTM Designation D1125 64.

YSI MODEL 33 AND 33M USED WITH YSI 51A, 54 and 57 OXYGEN METERS

If the salinity measurement is to be used for salinity correction on the 51A, the reading should be converted to Chlorosity. The formula is

$$\text{PPM Chlorosity} = \frac{\text{Salinity } ‰ - 0.03}{1.8} \times 10^3$$

For these instruments the 0.03 can be neglected so the equation simplifies to

$$\text{PPM Cl} = \frac{S ‰ \times 10^3}{1.8}$$

S ‰	0	9	18	27	36
PPM Cl	0	5,000	10,000	15,000	20,000

For salinity correction when using the Model 57 use the salinity reading direct from the Model 33 or 33M. No conversion is necessary.

Model 33 and 33M salinity readings taken in conjunction with Model 54 dissolved oxygen readings can be used to correct the Model 54 for salinity and to make post measurement salinity corrections to dissolved oxygen data. Correction tables are available from the factory.

WARRANTY

All YSI products carry a one year unconditional warranty on workmanship and parts, exclusive of batteries. Damage through accident, misuse, or tampering will be repaired at a nominal charge.

If you are experiencing difficulty with any YSI product, it may be returned to an authorized YSI dealer for repair, even if the warranty has expired. If you need factory assistance for any reason, contact:

Service Department
Yellow Springs Instrument Co., Inc.
P.O. Box 279
Yellow Springs, Ohio U.S.A.
Phone (513) 767 7241

APPENDIX C-5

CALIBRATION AND MAINTENANCE OF PHOTOVAC TIP

CALIBRATION AND MAINTENANCE OF PHOTOVAC TIP

CALIBRATION

Two basic calibration operations must be performed. These are adjustment of zero and the adjustment of span.

The zero adjustment is the easiest. Under conditions where accuracy is very important and sensitivity is less important, it may be sufficient to zero the instrument using outdoor air. In other cases, office area or indoor may prove to be clean enough for zeroing purposes. When rigorously done, a source of "Zero Air" or "Ultra Zero Air" is necessary. These are high purity grades of compressed air available in bottled form. The bottle is fitted with a regulator and can be connected directly to the TIP's input fitting. A very low rate of flow should be used with pressure applied never exceeding 1 psi (6 kPa.).

Having adjusted zero (this is best done with the "Span" control at maximum), we will now turn to span calibration. To assess a situation where there is a high ionizable loading in the air consisting of a mixture of many components, it must be recognized that any reading obtained will be a composite of the various components. With photoionization, response factors vary greatly from compound to compound. This makes the reading on TIP dependent upon both concentration and nature of the mixture involved. TIP, in this case, works as a scoping tool; the user can move around the contaminated area seeking "hot spots".

HNu calibration gas will be used to calibrate the TIP. The TIP probe will be inserted into the gas cylinder feeder base and the gas released. The TIP will then be adjusted to the gas concentration (generally 52 ppm).

MAINTENANCE

Routine maintenance requirements for TIP are minimal. All that is required is to assure the batteries remain close to full charge (during periods of non-use) and to assure that the inlet frit-filter is kept clear of debris. The frit is a sintered, stainless type and must be periodically replaced to assure free-flow of air to the detector.

Replacement of the frit is indicated when the inlet flow falls below 140 mL/min.

Referring to the TIP pictorial diagram, remove the four cover mounting screws holding the detector cover in place. Remove any inlet probe that may have been installed. Make sure the unit is switched "Off". Lift the detector cover straight off the front of TIP with a twisting motion to overcome friction against the seal. Take the cover and place it upside down against a soft, but firm, surface such as a block of wood, so that the inlet fitting will not be damaged. From the inside of the fitting, press out the filter with a tool such as a 1/16th inch hex screwdriver.

Turn the cover right side up and position the new filter squarely in the inlet fitting. Press it into position with the same tool.

Make sure that the black PID seal is in place in its recess in the TIP detector and slip the detector cover into position, twisting it over the seal. Replace the four cover mounting screws.

Further maintenance operations that can be performed by the user involve the cleaning of the ion chamber and the lamp window, replacement of the lamp and replacement of the battery pack.

The ion chamber is reached by removing the detector cover (as previously described), unplugging the yellow collector wire from the printed circuit board of the UHF driver, releasing the red repeller wire at its attachment point on the PID (loosen the small screw and pull gently free) and finally, unscrewing the PID from the lamp holder by grasping gently but firmly the body of the PID and rotating counterclockwise. The lamp will pop up on a spring and may be lifted out for cleaning/replacement. The interior of the ion chamber contains a very delicate wire mesh and must not be touched with any solid object. The lamp window may be cleaned with a cotton swab dipped in methanol and the interior of the ion chamber may be blown free of dust using a gentle compressed air jet. The lamp (or its replacement) is simply put back into the lamp holder and the PID screwed back into place being very careful to avoid "cross threading". The two wires are replaced as before. It is vital to assure that the PID seal is replaced in its seat before putting the cover back onto the detector.

If the pump and LEDs stay off for longer than a minute or so on a fully charged TIP, the detector lamp driving circuit may need adjustment. Remove the detector cover after which the pump and LEDs should come on as a result of ambient light hitting the photo resistor on the exposed circuit UHF driver circuit board.

Locate the ceramic trimming capacitor on the UHF driver; it has a screwdriver adjustment slot on the top of it. Be sure TIP is switched off, and make a pencil mark on the trimmer capacitor to indicate its original position. Turn the trimmer adjustment slightly (five degrees or so) in one direction or the other, then replace the detector cover and turn TIP "On". Repeat this procedure until the lamp starts. After TIP has run for two minutes or so, turn it off and set the trimmer back to its original position, or very near it, replace the detector cover, and use TIP.

If the lamp will not start regardless of the trimmer capacitor setting, the lamp likely needs replacing. Set the trimmer to its original position and replace the lamp as previously described. Lamp replacement is also indicated if, with fully charged batteries, TIP response drops drastically from one day to the next. Normally, a slight ozone smell will be present at the TIP vent. A failed lamp will not produce ozone.

[cac-65-18]

APPENDIX C-6

CALIBRATION AND MAINTENANCE OF HNU PHOTOIONIZER

CALIBRATION AND MAINTENANCE
OF HNU PHOTOIONIZATION DETECTOR

(Extracted from Manufacturer's Instruction Manual)

To zero the instrument, turn the function switch to the standby position and rotate the zero photentiometer until the meter reads zero. Clockwise rotation of the zero potentiometer produces an upscale deflection while counterclockwise rotation yields a downscale deflection. Note: no zero gas is needed, since this is an electronic zero adjustment (see below). If the span adjustment setting is changed after the zero is set, the zero should be rechecked and adjusted if necessary. Wait 15 or 20 seconds to ensure that the zero reading is stable. If necessary, readjust the zero.

The instrument is now ready for calibration or measurement by switching the function switch to the proper measurement range. The instrument is supplied calibrated to read directly in ppm (v/v) 0-20, 0-200, 0-2000 of benzene with the span position set at 9.8. For additional sensitivity, the span potentiometer is turned counterclockwise (smaller numbers) to increase the gain. By changing the span setting from 10.0 to 1.0, the sensitivity is increased approximately ten fold. Then, the 0-20, 0-200, 0-2000 ppm scales become 0-2, 0-20, and 0-200 ppm full scale, respectively.

The span control is also utilized to make the instrument scale read directly in ppm of the compound being measured. E.G., it is adjusted to match the value of a calibration gas to that same reading on the instrument scale. The span control can be utilized to calibrate nearly any compound measured by photoionization to be direct reading on the 0-20 ppm range. For example, gain settings of 4.5 or 8.9, respectively, will provide direct reading capability (0-20, 0-200 ppm) for vinyl chloride and trichloroethylene, respectively.

Place the HNU probe top into the calibration gas cylinder discharge hose and open the gas valve. Place the scale selector on 0-200 and adjust to the calibration gas concentration (generally 52 ppm) by turning the potentiometer. The instrument is now calibrated. Recheck and adjust the zero if necessary.

[cac-65-19]

WARZYN

APPENDIX C-7

CALIBRATION AND MAINTENANCE OF ORGANIC VAPOR ANALYZER (OVA) EXTRACTED FROM MANUFACTURERS INSTRUCTION MANUAL

Instruction & Service Manual

MI
2R900AC

CENTURY SYSTEMS

Portable Organic Vapor Analyzer
Model OVA-128

FOXBORO®

TABLE OF CONTENTS

INTRODUCTION

The Century Model OVA-128 Portable Organic Vapor Analyzer (OVA) is a highly sensitive instrument designed to measure trace quantities of organic materials in air. It is essentially a hydrogen flame ionization detector such as utilized in laboratory gas chromatographs and has similar analytical capabilities. The flame ionization detector is an almost universal detector for organic compounds with the sensitivity to analyze for them in the parts per million range (V/V) in air in the presence of moisture, nitrogen oxides, carbon monoxide and carbon dioxide.

The instrument has broad application, since it has a continuous, chemically resistant air sampling system and can be readily calibrated to measure almost all organic vapors. It has a single linearly scaled readout from 0 ppm to 10 ppm with a X1, X10, X100 range switch. Designed for use as a portable survey instrument, it can also be readily adapted to fixed remote monitoring or mobile installations. It is ideal for the determination of many organic air pollutants and in the monitoring of air in potentially contaminated areas.

The OVA-128 is certified intrinsically safe by Factory Mutual Research Corporation (FM) for use in Class I, Division 1, Groups A, B, C & D hazardous environments. Similar foreign certifications have been obtained, including BASEEFA and Cerchar approval for Group IIC, Temperature Class T4 and equivalent approval from the Japanese Ministry of Labor. This requirement is especially significant in industries where volatile flammable petroleum or chemical products are manufactured, processed or used and for instruments which are actually used in portable surveying and in analyzing concentrations of gases and vapors. Such instruments must be incapable, under normal or abnormal conditions, of causing ignition of the hazardous atmospheric mixtures. In order to maintain the certified safety, it is important that the precautions outlined in this manual be practiced and that no modification be made to these instruments.

Sections 1 through 6 herein apply to the basic instrument. Section 7 contains information relative to options which are available and which may or may not have been purchased with your OVA.

It is highly recommended that the entire manual be read before operating the instrument. It is essential that all portions relating to safety of operation and maintenance, including Section 5, be thoroughly understood.

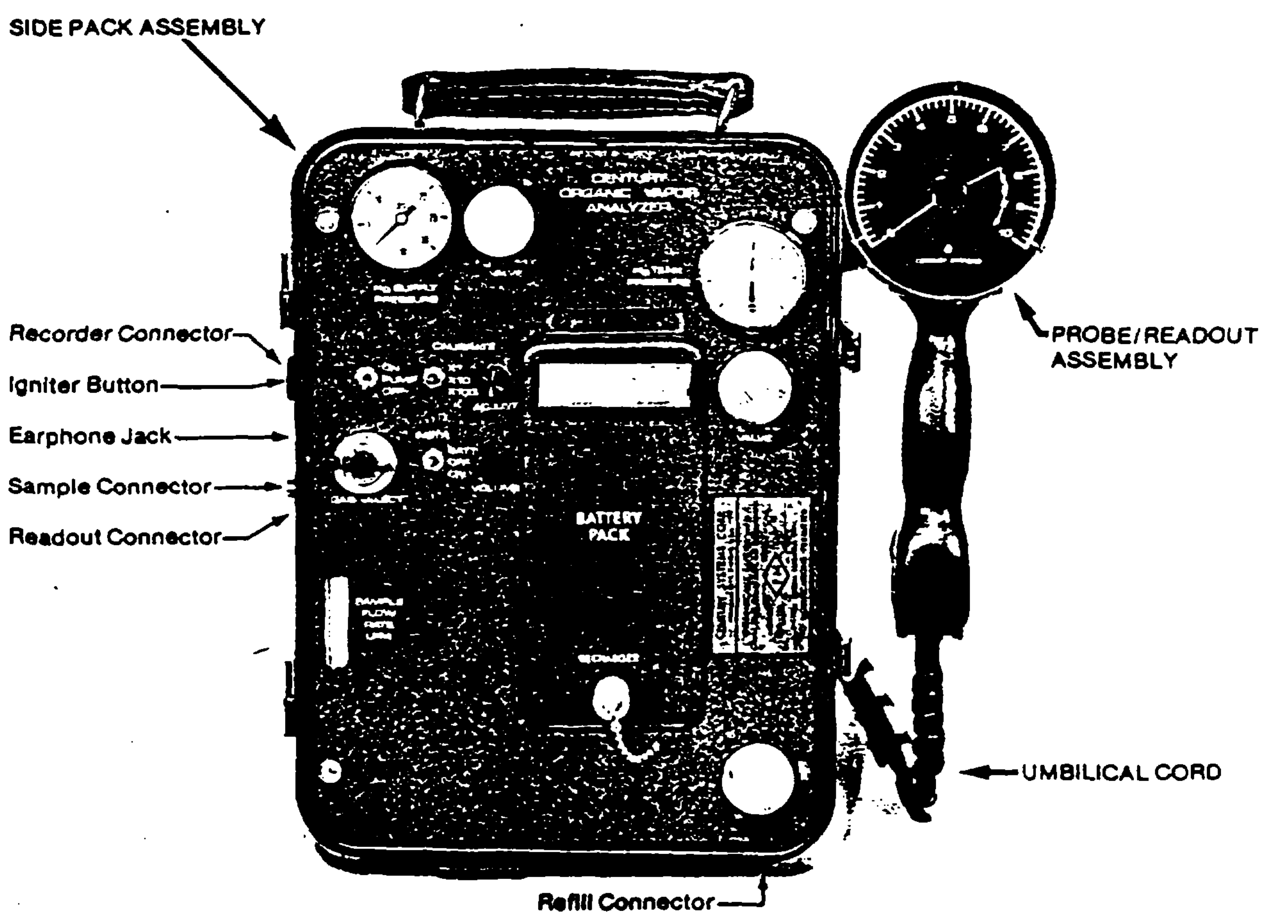


FIGURE 1-1. PORTABLE ORGANIC VAPOR ANALYZER
Model OVA-128

SECTION 1

DESCRIPTION AND LEADING PARTICULARS

1.1 GENERAL

The Century Portable Organic Vapor Analyzer (OVA), illustrated in Figure 1-1, is designed to detect and measure hazardous gases found in almost all industries. It has broad application, since it has a chemically resistant sampling system and can be calibrated to almost all organic vapors. It is extremely sensitive and can provide accurate indication of gas concentration in one of three ranges: 0 to 10 ppm; 0 to 100 ppm; and 0 to 1,000 ppm. While designed as a lightweight portable instrument, it can readily be adapted to remote monitoring applications.

The instrument utilizes the principle of hydrogen *flame ionization for detection and measurement* of organic vapors. The instrument measures organic vapor concentration by producing a response to an unknown sample, which can be related to a gas of known composition to which the instrument has previously been calibrated. During normal survey mode operation, a continuous sample is drawn into the probe and transmitted to the detector chamber by an internal pumping system. The sample flow rate is metered and passed through particle filters before reaching the detector chamber. Inside the detector chamber, the sample is exposed to a hydrogen flame which ionizes the organic vapors. When most organic vapors burn, they leave positively charged carbon-containing ions which are collected by a negative collecting electrode in the chamber. An electric field exists between the conductors surrounding the flame and the collecting electrode which drives the ions to the collecting electrode. As the positive ions are collected, a current corresponding to the collection rate is generated on the input electrode. This current is measured with a linear electrometer preamplifier which has an output signal proportional to the ionization current. A signal conditioning amplifier is used to amplify the signal from the preamp and to condition it for subsequent meter or external recorder display. The meter display is an integral part of the Probe/Readout Assembly and has a scale from 0 to 10.

1.2 TYPICAL APPLICATIONS

(1) Measurement of most toxic organic vapors present in industry for compliance with Occupational *Safety and Health Administration (OSHA)* requirements.
(2) Process monitoring and evaluation.
(3) Evaluation and monitoring applications in the air pollution field.
(4) Leak detection in storage, transportation and handling equipment.
(5) Survey of gas distribution and transmission lines and equipment for compliance with Office of Pipeline Safety (OPS) requirements.
(6) Forensic science applications.

1.3 OTHER TYPICAL USES

(1) Controlling and monitoring atmospheres in manufacturing and packaging operations.
(2) Mudlogging, gas and mineral exploration.
(3) Leak detection related to volatile fuel handling equipment.

1.4 MAJOR FEATURES

The basic instrument consists of two major assemblies, the Probe/Readout Assembly and the Side Pack Assembly (see Figure 1-1). The recorder is optional on all models, but is normally used with all instruments which incorporate the GC Option. The output meter and alarm level adjustments are incorporated in the Probe/Readout Assembly which is operated with one hand. The Side Pack Assembly contains the remaining operating controls and indicators, the electronic circuitry, detector chamber, hydrogen fuel supply and electrical power supply. It is a quantitative type instrument with sensitivity to 0.1 ppm methane.

Other major features are: 250° linear scale readout, less than two second response time and minimum eight hour service life for fuel supply and battery pack. A battery test feature allows charge condition to be read on the meter. Hydrogen flame-out is signified by an audible alarm plus a visual indication on the meter. The instrument contains a frequency modulated detection alarm which can be preset to sound at a desired concentration level. The frequency of the detection alarm varies as a function of detected level giving an audible indication of organic vapor concentration. The instrument is designed for one man, one hand operation and the entire unit weighs a total of less than 12 pounds, including fuel supply and battery. An earphone is provided for "only operator" monitoring.

During use, the Side Pack Assembly can be carried by the operator on either his left or right side or as a back pack. The Side Pack Assembly is housed in a high impact plastic case and weighs less than 10 pounds. The Probe/Readout Assembly can be detached from the Side Pack Assembly and broken down for transport and storage. See Figure 1-2 for the breakdown capability of the instrument.

1.5 ADAPTABILITY FEATURES AND STANDARD ACCESSORIES

1.5.1 GENERAL

Maximum flexibility and operability features are included in the instrument design. As shown in Figure 1-2, a variety of pickup fixtures can be used. They can be installed by simply turning a knurled locking nut. Small diameter tubing can be used for remote sampling and electrically insulated flexible extensions can be used for difficult places to reach.

1.5.2 PROBE

The telescoping probe allows the length to be increased or decreased over an eight inch range to suit the individual user. A knurled locking nut is used to lock the probe at the desired length. The probe is attached to the Readout Assembly using a knurled locking nut. For measurements in close areas, the probe is replaced with a Close Area Sampler, which is supplied as a standard accessory.

1.5.3 PARTICLE FILTERS

The primary filter is of porous stainless and located behind the sample inlet connector, see Side Pack Assembly drawing in Appendix "A". In addition, replaceable porous metal filters are installed in the "close area" sampler, the pickup funnel and the tubular sampler.

1.5.4 INSTRUMENT CARRYING CASE

An instrument carrying case is provided to transport, ship and store the disassembled Probe/Readout Assembly, the Side Pack Assembly and other standard equipment.

1.5.5 MOBILE INSTALLATION

The instrument is readily adaptable to a mobile application by simply plugging into vehicle power and hydrogen fuel supply and making provisions for drawing sample from the vehicle primary sampling system.

1.6 SPECIFICATIONS

Sensitivity: 0.1 ppm (methane)

Response time: Less than 2 seconds

Readout: 0 to 10 ppm, 0 to 100 ppm, 0 to 1,000 ppm, 250° linear scaled meter; external monitor connector

Sample flow rate: Nominally 2 units

Fuel supply: 75 cubic centimeter tank of pure hydrogen at maximum pressure of 2300 PSIG, fillable while in case

Primary electrical power: Rechargeable and replaceable battery pack at 12VDC

Service life: Hydrogen supply and battery power-8 hours operating time minimum

Size: Standard Unit: 8-5/8 x 11-5/8 x 4-1/4 FM Unit: 8-5/8 x 11-5/8 x 4-1/2 Probe/Readout Assembly: Variable (see Figure 1-2)

Weight: Standard Unit: Side Pack Assembly, less than 10 lbs. FM Unit: Side Pack Assembly, less than 11 lbs. Probe/Readout Assembly: less than 2 lbs.

Operator requirements: One man, one hand operation

Detection alarm: Frequency modulated audible alarm. Can be preset to desired level. Frequency varies as a function of detection level

Flame-out indication: Audible alarm plus visual meter indication

Battery test: Battery charge condition indicated on readout meter or battery recharger

Pickup fixtures: Variety of types for various applications

Probe: Telescoping adjustment over 8 inches or probe can be completely removed from Readout Assembly

Umbilical cord: Cable between readout and sidepack with connectors for electrical cable and sample hose

Filtering: In-line particle filters and optional activated charcoal filter.

Side Pack case: Molded high impact plastic case with carrying handle and shoulder strap

Electrical protection: Refer to Section 5

Standard accessories:

1) Instrument carrying and storage case
2) Fuel filling hose assembly
3) A.C. battery charger
4) Earphone
5) Various pickup fixtures

Optional accessories:

1) Gas chromatograph option
2) Portable strip chart recorder
3) Activated charcoal filter; also used with desiccant as a moisture trap
4) Dilution valve
5) Septum adapter for use with gas chromatograph option

SECTION 2

DETAILED OPERATING PROCEDURES

2.1 GENERAL

The procedures in this section are broken into five parts: (1) Starting, (2) Operating, (3) Shut Down, (4) Fuel Refilling, and (5) Battery Charging. After familiarization

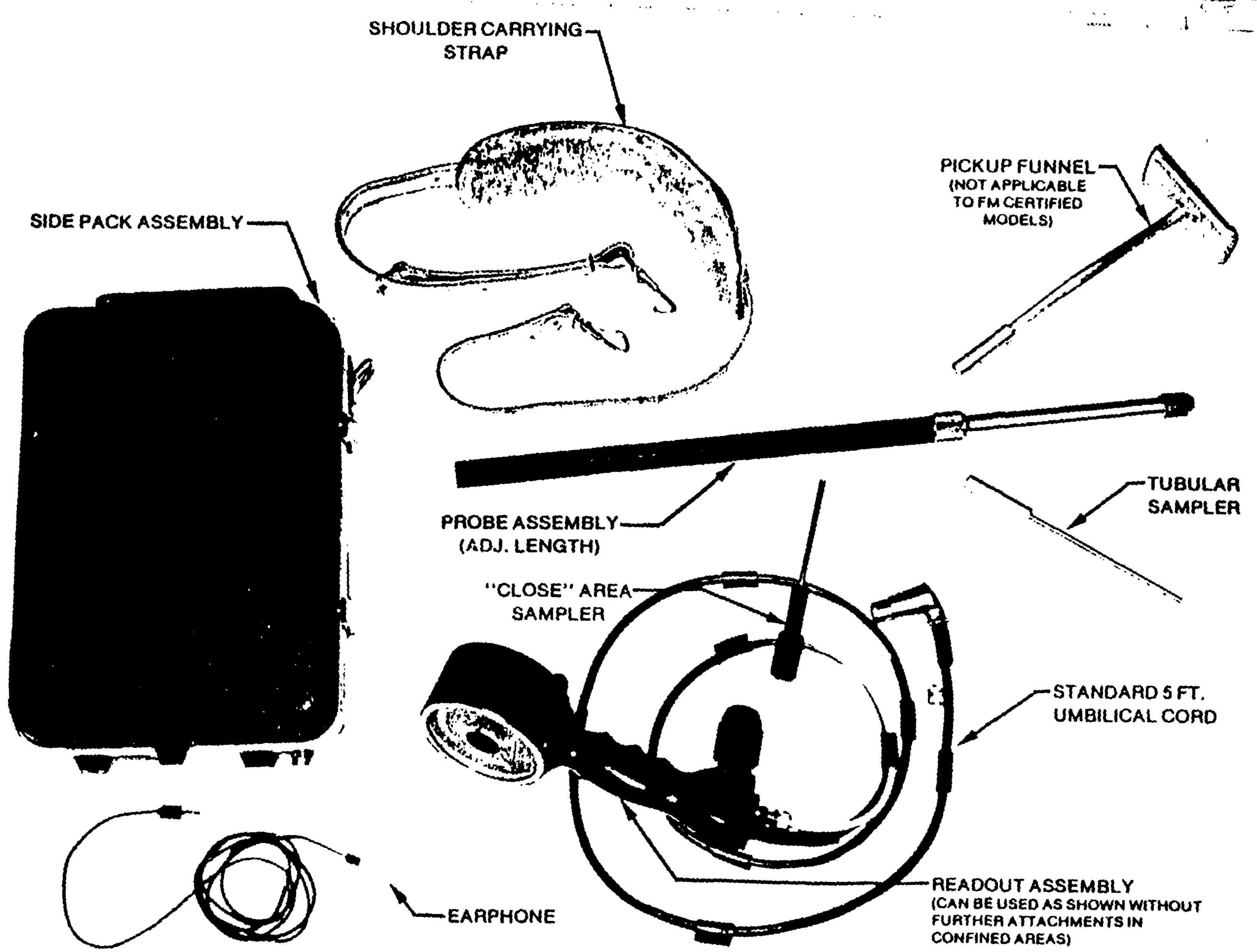


FIGURE 1-2

INSTRUMENT DISASSEMBLED

Typical of All Models Except Where Noted.

with the instrument, the summarized procedures described in Section 3 may be used for simplicity. Because of the many optional applications for the instrument, the comprehensive detailed procedures described in this section may seem complex. However, in normal applications the operating procedures are quite simple. A condensed operating procedure check list is provided inside the cover of the Side Pack Assembly. Refer to Section 7 for operating procedures relative to major optional accessories such as the Gas Chromatograph Option.

2.2 SYSTEM CONTROLS, INDICATORS AND CONNECTORS

Tables 2-1 and 2-2 describe the functions of the various controls, indicators and connectors illustrated in Figure 1-1. Unless otherwise noted, the listings in Tables 2-1 and 2-2 are applicable to both the Model OVA-118 and OVA-128.

TABLE 2-1
SIDE PACK ASSEMBLY

Controls/Indicators — Function

1) INSTR/BATT Test Switch - This 3 position toggle switch turns on all instrument electrical power except the pump and alarm power and also permits display of the battery charge condition on the readout meter.
2) PUMP (ON-OFF) Switch - This toggle switch turns on power to the internal pump and audio alarms.
3) Igniter Switch - This momentary push button switch connects power to the igniter coil in the detector chamber and simultaneously disconnects power to pump.
4) CALIBRATE Switch (range selector) - This 3 position toggle switch selects the desired range: X1 (0-10 ppm); X10 (0-100 ppm); X100 (0-1,000 ppm).
5) CALIBRATE ADJUST (zero) Knob - This potentiometer is used to "zero" the instrument.
6) GAS SELECT Knob (span control) - This ten-turn dial readout potentiometer sets the gain of the instrument commonly referred to as span control.
7) Recorder Connector - This 126 series 5-pin Amphenol connector is used to connect the instrument to an external monitor with the following pin connections.

   Pin E - plus 12VDC
   Pin H - Ground
   Pin A - Signal 0-5VDC (OVA-118 only)
   Pin B - Signal 0-5VDC (OVA-128 only)

8) Recharger Connector - This BNC connector is used to connect the battery pack to the battery recharger assembly.
9) H2 TANK VALVE - This valve is used to supply or close off the fuel supply from the hydrogen tank.
10) H2 TANK PRESSURE Indicator - This high pressure gauge measures the pressure in the hydrogen fuel tank which is an indication of fuel supply.
11) H2 SUPPLY VALVE - This valve is used to supply or close off the hydrogen fuel to the detector chamber.
12) H2 SUPPLY PRESSURE Indicator - This low pressure gauge is used to monitor the hydrogen pressure at the capillary restrictor.
13) SAMPLE FLOW RATE Indicator - This indicator is used to monitor the sample flow rate.
14) Refill Connection - This 1/4" AN fitting is used to connect the hydrogen refill hose to the instrument.
15) REFILL VALVE - This valve is used to open one end of the instrument fuel tank for refilling with hydrogen.
16) Earphone Jack - This jack is used to connect the earphone; it turns off speaker when used.
17) VOLUME Knob - This potentiometer adjusts the volume of the internal speaker and earphone.
18) Readout and Sample Connectors - These connectors are used to connect the sample hose and umbilical cord from the Probe/Readout Assembly to the Side Pack Assembly.

TABLE 2-2
PROBE/READOUT ASSEMBLY

Controls/Indicators — Function

A) Meter - This 250° linear scaled meter displays the output signal level in ppm.
B) Alarm Level Adjust Knob - This potentiometer (located on the back of the Readout Assembly) is used to set the concentration level at which the audible alarm is actuated.

2.3 STARTING PROCEDURE
2.3.1 INITIAL PREPARATION FOR USE
2.3.1.1 INITIAL ASSEMBLY (Reference Figure 1-2)

a) Normal Survey Configuration
   (1) Connect the adjustable length probe to the Readout Assembly with the captive locking nut. Ensure that the probe is seated firmly in the Readout Assembly.
   (2) Select the desired pickup fixture and check that a particle filter is installed.
   (3) Connect the pickup fixture to the probe using the knurled locking nut.
   (4) Connect the umbilical cord and sample hose to the Side Pack Assembly.
b) "Close Area" Survey Configuration
   (1) Check to ensure that a particle filter is installed in the close area sampler.
   (2) Connect the close area sampler directly to the Readout Assembly.
   (3) Connect the umbilical cord and sample hose to the Side Pack Assembly.

2.3.1.2 SERVICING

a) Fueling: Pure, dry hydrogen can normally be purchased locally or in a high grade from the Matheson Company of East Rutherford, New Jersey. The maximum instrument supply bottle pressure is 2300 PSIG. A high pressure hydrogen filling hose assembly is provided with the instrument. This assembly includes the proper fittings for the instrument and supply bottle, and a three-way fill/bleed valve. Initial fueling and subsequent refilling, using the Century high pressure filling hose, should be accomplished in accordance with the detailed instructions described in Section 2.6 of this manual.

b) Battery Check: Move INSTR/BATT Test Switch to the BATT position and ensure battery is charged by reading the indication on the readout meter.

c) Calibration: Standard factory calibration is performed using methane in air. The GAS SELECT (span) Control is set and locked to the position for calibration to methane (factory setting is 300). If the instrument is calibrated for other organic vapors, the reading on the GAS SELECT Control must be set for that particular vapor.

2.3.1.3 *SAFETY PRECAUTIONS*

Certain safety precautions must be followed in using the instrument. Hydrogen gas, when mixed with air, is highly flammable. Operating and refueling instructions should be strictly followed to ensure safe, reliable operation. Section 5 of the manual provides detailed safety precautions.

2.3.2 TURN ON PROCEDURE

The GAS SELECT control should be preset to the desired dial indication prior to turn on. The procedure for determining this setting is contained in Section 4 of this manual. The instrument, as received from the factory, is set to measure in terms of methane in air.

a) Move the INSTR Switch to ON and allow five minutes for warm up.

b) To set the audible alarm to a predetermined level, first turn the PUMP Switch to ON, then adjust the meter pointer to the desired alarm level, using the CALIBRATE ADJUST (zero) Knob. Turn the Alarm Level Adjust Knob on the back of the Readout Assembly until the audible alarm just comes on. Adjust speaker volume with VOLUME Knob. If earphone is used, plug in and readjust the volume as desired. The instrument is then preset to activate the alarm when the level exceeds that of the setting.

c) Move the CALIBRATE Switch to X10 and adjust the meter reading to zero with the CALIBRATE ADJUST (zero) Knob.

d) Ensure the PUMP Switch is ON and observe the SAMPLE FLOW RATE Indicator. Indication should be approximately 2 units.

e) Open H2 TANK VALVE one (1) turn and observe the reading on the H2 TANK PRESSURE Indicator. (Approximately 150 psi of pressure is needed for each hour of operation.)

f) Open H2 SUPPLY VALVE 1/2 to 1 turn and observe the reading on the H2 SUPPLY PRESSURE Indicator.

CAUTION

Do not leave H2 SUPPLY VALVE open when the pump is not running, as this will allow hydrogen to accumulate in the detector chamber.

g) Confirm that meter is still reading zero (readjust if required).

h) Depress igniter button. There will be a slight "pop" as the hydrogen ignites and the meter pointer will move upscale of zero. Immediately after ignition, release the igniter button. Do not depress igniter button for more than 6 seconds. If burner does not ignite, let instrument run for several minutes and try again. After ignition, the meter pointer will indicate the background concentration. This background level is nulled out using the CALIBRATE ADJUST (zero) Knob. Reference paragraph 6.2.5.1.

NOTE

Since the OVA utilizes the sample air drawn by the pump into the detector chamber as the only source of air to support the hydrogen flame, without adjustment the instrument will read the actual background concentration (ppm) of all hydrocarbons present at a given location.

i) Move instrument to an area which is representative of the "lowest ambient background concentration" (cleanest air) to be surveyed. Move the CALIBRATE Switch to X1 and adjust the meter to read 1 ppm with the CALIBRATE ADJUST (zero) Knob.

NOTE

Adjustment to 1 ppm (rather than 0) is necessary in the X1 range because of the sensitivity of the OVA. This permits minor downward fluctuations in the normal background level without dropping below 0, which would actuate the flame-out alarm. It is important, therefore, to remember during the subsequent survey that 1 ppm must be subtracted from all readings. Therefore, a 1.8 ppm reading would actually be only 0.8 ppm.

j) If the alarm level is to be set above the normal background detection level, turn the Alarm Level Adjust Knob on the back of the Readout Assembly until it actuates slightly above background.

THE INSTRUMENT IS NOW READY FOR USE.

2.4 OPERATING PROCEDURES

a) Set the CALIBRATE Switch to the desired range. Using one hand operation, survey the areas of interest while observing the meter and/or listening for the audible alarm indication. For ease of operation, carry the Side Pack Assembly positioned on the side opposite the hand which holds the Probe/Readout Assembly. For broad surveys outdoors, the pickup fixture should be positioned several feet above ground level. When making quantitative reading or pinpointing, the pickup fixture should be positioned at the point of interest.

b) When organic vapors are detected, the meter pointer will move upscale and the audible alarm will sound when the preset point is exceeded. The frequency of the audible alarm will increase as the detection level increases.

c) If the flame-out alarm is actuated, ensure that the pump is running, then press the igniter button. Under normal conditions, flame-out results from sampling a gas mixture that is above the lower explosive level which causes the H2 flame to extinguish. If this is the case, reignition is all that is required.
Another possible cause for flame-out would be restriction of the sample flow line which would not allow sufficient air into the chamber to support combustion of the H2 flame. The normal cause for such restriction would be a clogged particle filter or other restriction in the line.
It should be noted that the chamber exhaust port is on the bottom of the case and blocking this port with the hand will cause fluctuations and/or flame-out.

2.5 SHUT DOWN PROCEDURE

The following procedure should be followed for shut down of the instrument:

1) Close H2 SUPPLY VALVE.
2) Close H2 TANK VALVE.
3) Move INSTR Switch to OFF.
4) Wait 5 seconds and move PUMP Switch to OFF. INSTRUMENT IS NOW IN A SHUT DOWN CONFIGURATION.

2.6 FUEL REFILLING

a) The instrument should be completely shut down as described in Section 2.5 herein during hydrogen tank refilling operations. The refilling should be done in a ventilated area. There should be no potential igniters or flame in the area.

b) If you are making the first filling of the instrument or if the filling hose has been allowed to fill with air, the filling hose should be purged with N2 or H2 prior to filling the instrument tank. This purging is not required for subsequent fillings.

c) The filling hose assembly should be left attached to the hydrogen supply tank when possible. Ensure that the FILL/BLEED Valve on the instrument end of the hose is in the OFF position. Connect the hose to the refill connection on the Side Pack Assembly.

d) Open the hydrogen supply bottle valve slightly. Open the REFILL VALVE and the H2 TANK VALVE on the instrument panel and place the FILL/BLEED Valve on the filling hose assembly in the FILL position. The pressure in the instrument tank will now be indicated on the H2 TANK PRESSURE Indicator.

e) After the instrument fuel tank is filled, shut off the REFILL VALVE on the panel, the FILL/BLEED Valve on the filling hose assembly and the hydrogen supply bottle valve.

f) The hydrogen trapped in the hose should now be bled off to atmospheric pressure. CAUTION should be used in this operation as described in Step (g) below, since the hose will contain a significant amount of hydrogen at high pressure.

g) The hose is bled by turning the FILL/BLEED Valve on the filling hose assembly to the BLEED position. After the hose is bled down to atmospheric pressure, the FILL/BLEED Valve should be turned to the FILL position to allow the hydrogen trapped in the connection fittings to go into the hose assembly. Then, again, turn the FILL/BLEED Valve to the BLEED position and exhaust the trapped hydrogen. Then turn the FILL/BLEED Valve to OFF to keep the hydrogen at one atmosphere in the hose so that at the time of the next filling there will be no air trapped in the filling line.

h) Close the H2 TANK VALVE.

i) With the H2 TANK VALVE and the H2 SUPPLY VALVE closed, a small amount of H2 at high pressure will be present in the regulators and plumbing. As a leak check, observe the H2 TANK PRESSURE Indicator while the remainder of the system is shut down and ensure that the pressure indication does not go down rapidly, indicating a significant leak. If it does decrease rapidly (greater than 350 PSIG/hr.), there is a significant leak in the H2 supply system.

2.7 BATTERY RECHARGING

a) Plug charger BNC connector into mating connector on battery cover and insert AC plug into 115 VAC wall outlet. Never charge in a hazardous area or environment.

b) Move the battery charger switch to the ON position. The light above the switch button should illuminate.

c) Battery charge condition is indicated by the meter on the front panel of the charger; meter will deflect to the right when charging. When fully charged, the pointer will be in line with "charged" marker above the scale.

d) Approximately one hour of charging time is required for each hour of operation. However, an overnight charge is recommended. The charger can be left on indefinitely without damaging the batteries. When finished, move the battery charger switch to OFF and disconnect from the Side Pack Assembly.

The following are special instructions relative to batteries which have been allowed to completely discharge.

It has been established that the above battery recharging procedures may not be sufficient when the operator of the instrument has inadvertently left the INSTR Switch ON for a period of time without recharging and allowed the battery to completely discharge.

When this happens and the above procedures fail to recharge the battery, the following should be accomplished:

1) Remove the battery from the instrument case.
2) Connect to any variable DC power supply.
3) Apply 40 volts at 1/2 amp maximum.
4) Observe the meter on the power supply frequently and as soon as the battery begins to draw current, reduce the voltage on the power supply at a slow rate until the meter reads approximately 15 volts. NOTE: The time required to reach the 15 volt reading will depend on degree of discharge.
5) Repeat steps a), b), c), and d) above to continue charging.

2.7.2 DC CHARGER

a) The optional DC charger is designed to both charge the battery and to provide power for operating the instrument from a 12 volt DC source, such as vehicle power.
b) Connect the DC charger cord to the connector on the battery cover of the Side Pack Assembly. Plug the line cord into the vehicle cigarette lighter or other power source connection.
c) In mobile applications, the DC charger is used to supply vehicle power to the instrument. Therefore, it may be left connected at all times.

2.8 CHARCOAL FILTERING

When it is desired to preferentially remove the heavier hydrocarbons, such as those associated with automobile exhaust, gasoline, etc., simply remove the pickup fixture from the end of the probe and install the optional charcoal filter assembly.

This same charcoal filter assembly can be installed directly into the Readout Assembly by using the adapter provided.

2.9 MOISTURE FILTERING

Filtering of moisture in the sample is not normally required. However, when moving in and out of buildings in cold weather, excessive condensation can form in the lines and detector chamber. In this case, the charcoal filter adapter can be filled with a desiccant such as "Drierite" which will filter out the moisture contained in the sample.

SECTION 3

SUMMARIZED OPERATING PROCEDURES

3.1 GENERAL

The procedures presented in this section are intended for use by personnel generally familiar with the operation of the instrument. Section 2 presents the comprehensive detailed operating procedures.

It is assumed that, prior to start up the positions of all switches and valves are in shut down configuration as described in paragraph 3.3.

3.2 START UP

a) Move PUMP Switch to ON and check battery condition by moving the INSTR Switch to the BATT position.
b) Move INSTR Switch to ON and allow five (5) minutes for warm-up.
c) Set Alarm Level Adjust Knob on back of Readout Assembly to desired level.
d) Set CALIBRATE Switch to X10 position, use CALIBRATE Knob and set meter to read 0.
e) Move PUMP Switch to ON position then place instrument panel in vertical position and check SAMPLE FLOW RATE indication.
f) Open the H2 TANK VALVE and the H2 SUPPLY VALVE.
g) Depress Igniter Button until burner lights. Do not depress Igniter Button for more than six (6) seconds. (If burner does not ignite, let instrument run for several minutes and again attempt ignition.)
h) Use CALIBRATE Knob to "zero" out ambient background. For maximum sensitivity below 10 ppm, set CALIBRATE Switch to X1 and readjust zero on meter. To avoid false flame-out alarm indication, set meter to 1 ppm with CALIBRATE Knob and make differential readings from there.

3.3 SHUT DOWN

a) Close the H2 SUPPLY VALVE and the H2 TANK VALVE.
b) Move the INSTR Switch and PUMP Switch to OFF.
c) Instrument is now in shut down configuration.

SECTION 4

CALIBRATION

4.1 GENERAL

The OVA is capable of responding to nearly all organic compounds. For precise analyses it will be necessary to calibrate the instrument with the specific compound of interest. This is especially true for materials containing elements other than carbon and hydrogen.

The instrument is factory calibrated to a methane in air standard. However, it can be easily and rapidly calibrated to a variety of organic compounds. A GAS SELECT control is incorporated on the instrument panel which is used to set the electronic gain to a particular organic compound.

Internal electronic adjustments are provided to calibrate and align the electronic circuits. There are four (4) such adjustments all located on the electronics board. One adjustment potentiometer, R-38, is used to set the power supply voltage and is a one-time factory adjustment. The remaining three adjustments, R-31, R-32 and R-33 are used for setting the electronic amplifier gain for each of the three (3) calibrate ranges. Access to the adjustments is accomplished by removing the instrument from its case. Figure 4-1 indicates the location of the adjustments.

4.2 ELECTRONIC ADJUSTMENTS

Primary calibration of this instrument is accomplished at the factory using methane in air sample gases.

4.2.1 GAIN ADJUSTMENT

a) Place instrument in normal operation with CALIBRATE Switch set to X10 and GAS SELECT control set to 300.
b) Use the CALIBRATE ADJUST (zero) Knob and adjust the meter reading to zero.
c) Introduce a methane sample of a known concentration (near 100 ppm) and adjust trimpot R-32 on circuit board (see Figure 4-1 for location) so that meter reads equivalent to the known sample.
d) This sets the instrument gain for methane with the panel mounted gain adjustment (GAS SELECT) set at a reference number of 300.
e) Turn off H2 SUPPLY VALVE to put out flame.

4.2.2 BIAS ADJUSTMENT

a) Leave CALIBRATE Switch on X10 position and use CALIBRATE ADJUST (zero) Knob to adjust meter reading to 4 ppm.
b) Place CALIBRATE Switch in X1 position and, using trimpot R-31 on circuit board, adjust meter reading to 4 ppm. (See Figure 4-1)
c) Move CALIBRATE Switch to X10 position again. Use CALIBRATE ADJUST (zero) Knob to adjust meter to a reading of 40 ppm.
d) Move CALIBRATE Switch to X100 position and use trimpot R-33 on circuit board to adjust meter reading to 40 ppm.
e) Move CALIBRATE Switch to X10 position and use CALIBRATE ADJUST (zero) Knob to adjust meter reading to zero.
f) Unit is now balanced from range to range, calibrated to methane, and ready to be placed in normal service.

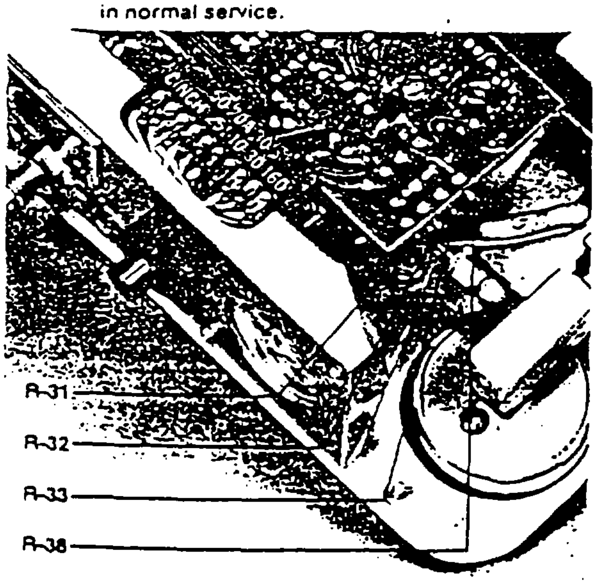


FIGURE 4-1. LOCATION OF ELECTRONIC ADJUSTMENTS
(Model OVA-118 shown; location typical to OVA-128)

4.3 CALIBRATION TO OTHER ORGANIC VAPORS

4.3.1 SETTING GAS SELECT CONTROL (Span)

Primary calibration of the instrument is accomplished using a known mixture of a specific organic vapor compound. After the instrument is in operation and the "normal background" is "zeroed out", draw a sample of the calibration gas into the instrument. The GAS SELECT Knob on the panel is then used to shift the readout meter indication to correspond to the concentration of the calibration gas mixture.

The instrument is then calibrated for the vapor mixture being used. After this adjustment, the setting on the "digidial" is read and recorded for that particular organic vapor compound. This exercise can be performed for a large variety of compounds and when desiring to read a particular compound the GAS SELECT control is turned to the predetermined setting for the compound. Calibration on any one range automatically calibrates the other two ranges.

4.3.2 USING EMPIRICAL DATA

Relative response data may be obtained, which can then be used to estimate concentrations of various vapors. With the instrument calibrated to methane, obtain the concentration reading for a calibration sample of the test vapor. The relative response, in percent, for that test vapor would then be the concentration read/concentration of the calibrated sample X 100.

4.3.3 PREPARATION OF CALIBRATION STANDARDS

4.3.3.1 COMMERCIAL SAMPLES

Commercially available standard samples offer the most convenient and reliable calibration standards and are recommended for the most precise analyses. Always remember to obtain the cylinder with the desired sample and the "balance as air". Sample should be drawn from the cylinder into a collapsed sample bag, then drawn from the bag by the instrument to prevent a pressure or vacuum at the sample inlet.

4.3.3.2 PURE GASEOUS SAMPLES

Obtain a large collapsible sample bag, preferably polyethylene such as a 40 gallon trash can liner. Insert a tube into the bag opening and tie shut around the tube. The tubing should have a shut-off valve or plug and be suitable for connecting the OVA input tube. Determine the volume of the bag by appropriate means (i.e., wet-test meter, dimensions of the bag, etc.). Forty gallon polyethylene bags provide a volume of approximately 140-160 liters. For gas samples, flush a 10 cc hypodermic syringe with the compound to be tested and then inject a 10 cc sample through the wall of the air-filled bag. Immediately after withdrawing the needle, cover the hole with a piece of plastic tape. Allow a few minutes for the sample to completely diffuse throughout the bag. Agitation will ensure complete diffusion. Connect the outlet tube to the OVA and take a reading. To verify repeatability of sampling technique, disconnect the bag and inject a second sample of the gas into the bag without emptying. Since only 2 or 3 liters will have been removed, the overall volume change will be small and the instrument reading should now be twice that of the original. The concentration in ppm (V/V) will be equal to the sample size in cc divided by the volume of the bag in liters times 1000. For example, a 10 cc gas sample when placed in a 160 liter bag will provide a sample of 63 ppm, i.e., 10 X 1000/160 equals 63 ppm.

4.3.3.3 GASEOUS AND LIQUID SAMPLES (Alternate Method)

Obtain a five (5) gallon glass bottle and determine its volume by measuring the volume of water needed to fill it (use of a 1000 ml graduated cylinder, obtainable from scientific supply houses, is convenient). Another approach is to weigh the empty bottle, fill it with water and weigh again. The difference between the two values is the weight of water. By multiplying the weight of water in pounds by 0.455, you obtain the volume of the bottle in liters. Empty the water out and allow the bottle to dry. Place a one-foot piece of plastic tubing in the flask to aid in mixing the vapors uniformly with the air. The volume of such a bottle should be about 20 liters, which is 20,000 ml. If the volume were 20,000 ml, then a 2 ml sample of a gas placed in the bottle would be equivalent to 200 ml per 2 million ml or 100 ppm (V/V). Use of a gas tight syringe, readable in 0.01 ml, allows the preparation of mixtures in the 1 - 2 ppm range, which are sufficient for the quantitative estimation of concentrations. A rubber stopper is loosely fitted to the top of the bottle and the needle of the syringe placed inside the jug neck and the stopper squeezed against the needle to decrease leakage during sample introduction. Inject the sample into the bottle and withdraw the needle without removing the stopper. Put the stopper in tight and shake the bottle for a few minutes with sufficient vigor that the plastic tubing in the bottle moves around to ensure good mixture of the vapors with the air.

For liquid samples, use of the following equation will allow the calculation of the number of microliters of organic liquid needed to be placed into the bottle to make 100 ppm (V/V) of vapor.

V1 equals V2 X Mw/244D

- V1 - Volume of liquid in microliters needed to make an air mixture of 100 ppm (V/V)
- V2 - Volume of bottle in liters
- Mw - Molecular weight of substance
- D - Density of substance

This procedure has the advantage that you can see when all of the organic liquid has vaporized and the volume can be determined readily.

For liquid samples, an alternate procedure involves the use of a diffusion dilution device such as that described by Desty, Geach and Goldup in "Gas Chromatography", R.P.W. Scott, ed., Academic Press, New York, 1961.

4.4 THEORY

Theoretical background and empirical data related to the Century Organic Vapor Analyzer is presented in 4.4.1 and 4.4.2.

4.4.1 HYDROCARBONS

In general, a hydrogen flame ionization detector is more sensitive for hydrocarbons than any other class of organic compounds. The response of the OVA varies from compound to compound, but gives excellent repeatable results with all types of hydrocarbons; i.e., saturated hydrocarbons (alkanes), unsaturated hydrocarbons (alkenes and alkynes) and aromatic hydrocarbons.

The typical relative response of various hydrocarbons to methane is as follows:

Compound	Relative Response (percent)
Methane	100 (reference)
Propane	64
N-butane	61
N-pentane	100
Ethylene	85
Acetylene	200
Benzene	150
Toluene	120
Ethane	90

4.4.2 OTHER ORGANIC COMPOUNDS

Compounds containing oxygen, such as alcohols, ethers, aldehydes, carbolic acid and esters give a somewhat lower response than that observed for hydrocarbons. This is particularly noticeable with those compounds having a high ratio of oxygen to carbon such as found in the lower members of each series which have only one, two or three carbons. With compounds containing higher numbers of carbons, the effect of the oxygen is diminished to such an extent that the response is similar to that of the corresponding hydrocarbons.

Nitrogen-containing compounds (i.e., amines, amides and nitriles) respond in a manner similar to that observed for oxygenated materials. Halogenated compounds also show a lower relative response as compared with hydrocarbons. Materials containing no hydrogen, such as carbon tetrachloride, give the lowest response; the presence of hydrogen in the compounds results in higher relative responses. Thus, $CHCl_3$ gives a much higher response than does CCl_4. As in the other cases, when the carbon to halogen ratio is 5:1 or greater, the response will be similar to that observed for simple hydrocarbons.

The typical relative response of various compounds to methane is as follows:

Methane	100 (calibration sample)
Ketones	
Acetone	60
Methyl ethyl ketone	80
Methyl isobutyl ketone	100
Alcohols	
Methyl alcohol	15
Ethyl	25
Isopropyl	65

Halogen compounds

Carbon tetrachloride	10
Chloroform	65
Trichloroethylene	70
Vinyl chloride	35

The OVA has negligible response to carbon monoxide and carbon dioxide which evidently, due to their structure, do not product appreciable ions in the detector flame. Thus, other organic materials may be analyzed in the presence of CO and CO_2.

SECTION 5

SAFETY CONSIDERATIONS

5.1 GENERAL

The Models OVA-108, OVA-128 and OVA-138 have been tested and certified by Factory Mutual Research Corporation (FM) as intrinsically safe for use in Class I, Division 1, Groups A, B, C & D hazardous atmospheres. Similar foreign certifications have been obtained, including BASEEFA and Cerchar approval for Group IIC, Temperature Class T4 on the Models OVA-108, OVA-128 and OVA-138, and equivalent approval from the Japanese Ministry of Labor for the Model OVA-128. Special restrictions must be strictly adhered to, to ensure the certification is not invalidated by actions of operating or service personnel.

All flame ionization hydrocarbon detectors are potentially hazardous since they burn hydrogen (H2) or H2 mixtures in the detector cell. Mixtures of H2 and air are flammable over a wide range of concentrations whether an inert gas such as nitrogen (N2) is present or not. Therefore, the recommended precautions and procedures should be followed for maximum safety. Safety considerations was a major factor in the design of the Organic Vapor Analyzer (OVA).

All connectors are of the permanent type as opposed to quick disconnect. To protect against external ignition of flammable gas mixtures, the flame detection chamber has porous metal flame arrestors on the sample input and the exhaust ports as well as on the H2 inlet connector. The standard battery pack and other circuits are internally current limited to an intrinsically safe level.

5.2 OPERATING, SERVICING AND MODIFYING

It is imperative that operation and service procedures described in this manual be carefully followed in order to maintain the intrinsic safety which is built into the OVA. No modification to the instrument is permissible. Therefore, component replacement must be accomplished with the same type parts.

5.3 ELECTRICAL PROTECTION

The 12V battery power supply circuit is current limited to an intrinsically safe level. Fuses are not utilized and all current limiting resistors and other components which are critical to the safety certification are encapsulated to prevent inadvertent replacement with components of the wrong value or specification. Under no circumstances should the encapsulation be removed.

5.4 FUEL SUPPLY & TANK

The OVA fuel tank has a volume of 75 to 85 cc which, when filled to the maximum rated pressure of 2300 PSIG, holds approximately 5/8 cubic foot of gas. The fuel used in the OVA is pure hydrogen which can be readily purchased in a highly pure form at nominal cost. The H2 tanks used in the instrument are made from stainless steel, proof-tested to 6,000 PSIG and 100% production tested to 4,000 PSIG.

5.5 H2 FLOW RESTRICTORS

Hydrogen gas gains heat when expanding and, therefore, should not be rapidly released from a high pressure tank to a low pressure environment. Flow restrictors are incorporated in the H2 refill fitting and H2 is restricted on the output side of the tank by the low flow rate control system. In addition, a special flow restrictor is incorporated in the FILL/BLEED valve of the hydrogen filling hose assembly. These precautions limit the flow rate of the H2 to prevent ignition due to self-heat from expansion.

5.6 DETECTOR CHAMBER

The OVA has a small flame ionization chamber cavity with sintered metal flame arrestors on both the input and output ports. The chamber is ruggedly constructed of teflon such that even if highly explosive mixtures of H2 and air are inadvertently created in the chamber and ignited, the chamber would NOT rupture.

5.7 H2 FILLING AND EMPTYING OPERATIONS

Precautions should be taken during H2 filling or H2 tank emptying operations to ensure that there are no sources of ignition in the immediate area. Since the instrument tank at 2300 PSIG holds only 5/8 cu. ft. of H2, the total quantity, if released to the atmosphere, would be quickly diluted to a non-flammable level. There is, however, the possibility of generating flammable mixtures in the immediate vicinity of the instrument during the filling or emptying operations if normal care is not exercised.

5.8 VENTING

The OVA case is vented to eliminate the possibility of trapping an explosive mixture of H2 and air inside the case.

SECTION 6

MAINTENANCE

6.1 GENERAL

This section describes the routine maintenance schedule recommended and provides procedures for trouble shooting malfunctions or failures in the instrument.

Appendix "A" to this manual contains the assembly drawings and associated parts list for the Side Pack Assembly and two major subassemblies; the Electronic Component Assembly and the Cylinder Assembly. These drawings and parts lists may be used for locating and identifying components. Also included in Appendix "A" is a schematic wiring diagram showing interconnecting wiring between major electronic assemblies and typical signal levels at selected points on the certified instruments. The enclosed drawings and parts lists are subject to change without notice and part replacement on any certified instrument should be verified to comply with the "no modifications permitted" requirement.

CAUTION

Maintenance personnel should be thoroughly familiar with instrument operation before performing maintenance. It is essential that all portions of this manual relating to safety of operation, servicing and maintenance, including Section 5, be thoroughly understood. There should be no potential igniters or flame in the area when filling, emptying or purging the hydrogen system and the instrument should be turned off.

Extreme care should be exercised to ensure that required parts replacement is accomplished with the same parts specified by Century. This is especially necessary on the Models OVA-108, OVA-128 and OVA-138 in order that their certification for use in hazardous atmospheres be maintained. No modifications are permitted. Disassemble instrument only in a non-hazardous atmosphere.

6.2 ROUTINE MAINTENANCE

Note that Figure 6-1 is a flow diagram of the basic gas handling system.

6.2.1 FILTERS

6.2.1.1 PRIMARY FILTER

This filter is located behind the sample inlet connector (Fitting Assembly) on the Side Pack Assembly and is removed for cleaning by using a thin wall socket to unscrew the Fitting Assembly. The filter cup, "O" ring and loading spring will then come out as shown in the Side Pack Assembly drawing in Appendix "A". The porous stainless filter cup can then be cleaned by blowing out or washing in a solvent. If a solvent is used, care should be taken to ensure that all solvent is removed by blowing out or heating the filter. Reassemble in reverse order ensuring that the "O" ring seal on the Fitting Assembly is intact.

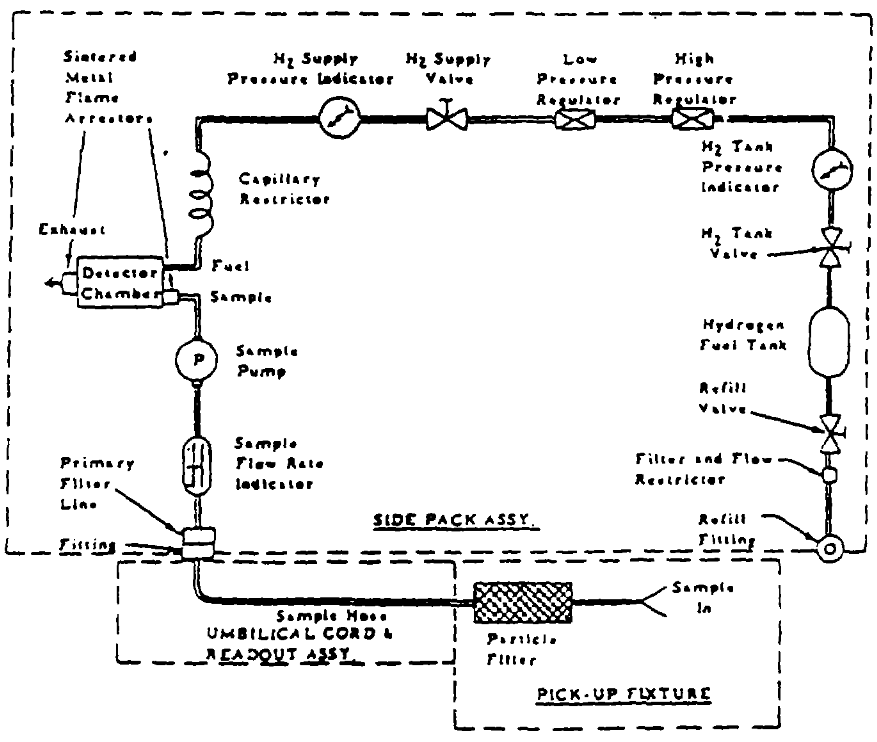


FIGURE 6-1. Flow Diagram - Gas Handling System

6.2.1.2 PARTICLE FILTERS

A particle filter is located in each pickup fixture. One of these filters must be in the sample line whenever the instrument is in use. The Models OVA-88 and OVA-138 use a disposable cellulose filter which should be changed as often as required. The Models OVA-98, OVA-108, OVA-118 and OVA-128 use a porous metal filter which can be replaced or cleaned using the cleaning procedure in paragraph 6.2.1.1.

6.2.1.3 MIXER/BURNER ASSEMBLY FILTER

Another porous metal particle filter is incorporated in the Mixer/Burner Assembly which screws into the Preamp Assembly. See Side Pack Assembly drawing. This filter is used as the sample mixer and inlet flame arrestor in the chamber. This filter should not become contaminated under normal conditions but can be cleaned or the assembly replaced if necessary.

Access to this filter for output surface cleaning is gained by simply unscrewing the exhaust port from the Preamp Assembly without removing the instrument from the case. The OVA-108, OVA-128 and OVA-138 instruments require removal of the safety cover prior to unscrewing the exhaust port. The Filter Assembly can now be seen on the side of the chamber (Preamp Assembly) and can be scrapped or cleaned with a small wire brush.

If filter replacement is required, install a new or factory rebuilt Mixer/Burner Assembly. In several OVA models, this requires removal of the Preamp Assembly.

6.2.1.4 EXHAUST FLAME ARRESTOR

A porous metal flame arrestor is located in the exhaust port of the detector chamber (Preamp Assembly). See Side Pack Assembly drawing. It acts as a particle filter on the chamber output and restricts foreign matter from entering the chamber. This filter may be cleaned, if required, by removing the exhaust port from the Preamp Assembly. The exhaust port is removed from the bottom of the case without case removal. Note that the filter is captive to the exhaust port on the Models OVA-108, OVA-128 and OVA-138. Clean the filter with a solvent or detergent but ensure that it is dry and any solvent completely baked out at 120°F before reinstalling.

6.2.2 PICKUP FIXTURES

The pickup fixtures should be periodically cleaned with an air hose and/or detergent water to eliminate foreign particle matter. If a solvent is used, the fixture should be subsequently cleaned with detergent and baked out at 120°F to eliminate any residual hydrocarbons from the solvent.

6.2.3 SEAL MAINTENANCE - CYLINDER ASSEMBLY

6.2.3.1 H2 TANK, H2 SUPPLY AND REFILL VALVES

After some time, the teflon washers under each valve packing nut can "cold flow" (move with pressure) and allow hydrogen to leak. Leakage can be determined by using Leak-Tec, Snoop or a soap solution around the valve stems. This leakage can usually be stopped by tightening the compression nut (adapter) as outlined below. See Side Pack Assembly and Cylinder Assembly drawings.

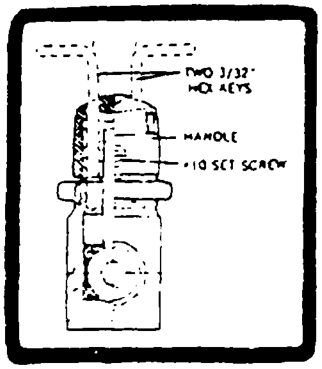
1) Remove instrument from the case by unlocking the four (4) 1/4 turn fasteners on the panel and removing the exhaust safety cover (if included), exhaust port and refill cap nut. Be sure refill valve is closed before removing refill cap nut.
2) Remove the valve knob screw and knob.
3) Loosen the panel nut with a 3/4" wrench.
4) The valve compression nut is located just under the panel. Tighten the compression nut—usually not more than 1/4 turn.

This compression is against soft material and only a small amount of force is necessary to sufficiently compress the teflon washers. If, after tightening, leakage still occurs, it would be advisable to replace the two teflon washers, as follows:

1) Drain hydrogen system slowly and to the extent necessary to work on the leaking valve(s). Observe safety precautions (see Section 5). There should be no potential igniters in the area.
2) Disconnect the capillary tube from the manifold at low pressure gauge (H2 Supply Pressure).
3) Remove all three (3) knob screws and knobs.
4) Remove the three (3) panel nuts and washers.
5) Carefully remove the tank assembly from the panel. NOTE: If OVA has GC Option installed, the GC valve assembly must be loosened or removed in order to remove the tank assembly from the panel.
6) Remove the compression nut on the valve that is not sealing properly. Remove the stem by unscrewing it from the valve body. Observe the sandwich of metal and teflon washers and note their order.
7) Visually check the Kel-F seat on the stem for cracks or foreign material. Wipe clean, if necessary, with a lint free cloth (no solvents or oils) and replace if damaged.
8) Remove the washers and replace the teflon washers (the factory procedure is a light wipe of hydrocarbon free silicone grease).
9) Replace the stem assembly in the valve body and tighten lightly.
10) Push the washers down into the compression area in the same order as noted upon removal. Replace the compression nut and tighten snugly.
11) Close the low pressure valve and fill the tank assembly. Check valves for leaks. Tighten again, if necessary, and reassemble the unit.

6.2.3.2 REFILLER VALVE PACKING ADJUSTMENT

Adjustment for the valve on the refiller can be made by loosening the set screw with a 3/32" hex key, so that the handle turns freely on the stem. Insert two (2) 3/32" hex keys through the holes provided in the handle and turn until they engage the holes in the packing adjuster. Then tighten the packing by turning the handle.



AIR SAMPLING SYSTEM MAINTENANCE
· GENERAL
:ential problem associated with the OVA instru- that leaks can develop in the air sample pump- stem. These leaks can result in either dilution or sample, causing low reading of vapor concentra- d slow response time.

: TESTING FOR LEAKS
· OVA's are equipped with a flow gauge, which :s a method to check for air leaks. Assemble the probe selected for use to the readout assembly ien position the sidepack vertically so the flow may be observed. Cover the end of the pickup with your finger and observe that the ball in the uge goes to the bottom, indicating no air flow (if as slight chatter while on bottom, this is accep- · Cover the center of the chamber exhaust port ur thumb and again observe the ball going to the · Another simple check is to expose the pickup to cigarette smoke or a light vapor (butane) and ve that the meter responds in approximately 1.5 - conds. It should be noted that slow meter ise may also indicate a restriction in the air ng system.

3 LEAK ISOLATION
ire of the ball to go to the bottom when the inlet is d indicates a leak in the system between the pro- d the pump inlet or the inlet check valve. To isolate roblem, remove parts, one at a time, and again off the air inlet. Remove the pickup probe(s) and the air inlet at the Readout Assembly. If the ball to the bottom, check that the "readout to probe" washer is in place and replace the probes, holding back against this seal while tightening the nut. :ck, and if leakage is still present, it is probably in obe (pickup fixture), which should be repaired or :ed.
akage is indicated as being past the readout han- hen the connection to the sidepack is tight, nect the sample line at the fitting on the sidepack over this inlet with your finger. If the flow gauge ball goes to the bottom, the problem should be a leak in the umbilical cord/Readout Assembly, which should be investigated and repaired. There is also the possibility of a leaking check valve in the pump which would not show up on this test. If the leakage is not found in the umbilical cord, it is most likely in the pump check valve which should be repaired or replaced.

If the ball does not go to the bottom, the leak will be either in the flow gauge or it's connecting tubing. Visually check that the tubing is connected and if so, the flow gauge should be repaired or replaced. Check the "O" ring installation in the sample inlet connector (Fitting Assembly).

As an alternate approach, leaks on the inlet side of the pump can be detected by using alcohol on a "Q" Tip and lightly swabbing the connections one at a time or by directing organic vapor or smoke at the potential leakage points and observing the meter response or audible alarm.

Leaks (beyond the pump) are easier to locate, as any of the commercially available leak detection solutions can be used. Cover the exhaust port, which will place the exhaust system under pressure, and check each connection, one at a time. Replace the teflon tubing or retape the threaded connections with teflon joint tape. Check the igniter and Mixer/Burner Assembly where they screw into the detector, the high voltage terminal screw on the side of the Mixer/Burner and exhaust port itself. If after these checks, the flow gauge ball still will not go to the bottom with the exhaust blocked, the problem is likely a leaking exhaust check valve in the pump, which should be repaired or replaced.

6.2.5 CONTAMINATION CONTROL AND MAINTENANCE
6.2.5.1 GENERAL
On occasion, the background reading of the OVA may be relatively high under normal ambient conditions. Ambient background readings will vary somewhat depending on the geographical location where the instrument is being used. However, the background reading normally should be in the range of 3 to 5 ppm as methane. The acceptable background reading consists of 1 to 1-1/2 ppm of methane which is present in the normal air environment. In addition to the measurement of a normal methane background, there will normally be 2 to 4 ppm of equivalent methane background caused by acceptable levels of contamination in the hydrogen fuel and/or hydrogen fuel handling system resulting in a total equivalent methane reading of 3 to 5 ppm in clean air.

If the background reading goes above 5 ppm to 6 or 7 ppm, this is normally still acceptable since any measurement is additive to that background reading, i.e., 2 ppm on top of 5 or 2 ppm on top of 7 provides the same differential reading, however, the lower background is obviously desirable.

The background reading on the linear OVA's is zeroed out or nulled out—even though in reality the background still exists. The background reading on the linear OVA's is measured by zeroing the meter with the flame out and noting the meter indication after the flame is on. However, on the logarithmic scaled OVA's the background reading is observed on the meter at all times. This is considered desirable since it assures the operator that the instrument is, in fact, operating properly. The background reading on the OVA's serves as a low level calibration point since it does represent the measurement of ambient levels of methane in the air, which are extremely stable and predictable any place in the world.

The cause for a high background reading is usually associated with contamination in the hydrogen fuel system. This will, of course, cause a background reading since this is the function of the basic detector "to measure contamination entering the detector chamber". In addition, contamination present in the hydrogen will many times leave a small unobservable deposit on the burner face which can continue to generate a background reading when the detector is in operation and the burner assembly is heated.

Another possible cause of contamination is the mixer/burner assembly when the contamination is trapped in the porous bronze sample filter. This is not a common problem and usually only happens when an unusually high level of contaminant is drawn into the assembly. Another possible cause of high background reading is contamination someplace in the air sample line to the detector. This is also uncommon but can be the source of the problem.

NOTE

OVA's that include the Chromatograph Option installed can also have an indication of high background related to saturation or contamination of the activated charcoal filter, which is in the line during chromatograph analysis, or of the column which is in the hydrogen line at all times.

6.2.5.2 ANALYSIS AND CORRECTION

Prior to analyzing the problem, the OVA should be checked for proper electronic operation. Check logarithmic instruments for proper high and low calibration points and for proper gas selector operation (see Section 4). On logarithmic OVA's, check Gas Selector by turning to 500 and observing the flame-out alarm comes on as the needle goes below 1 ppm. It should be ensured that the instrument is calibrated to methane as referenced.

If, after checking that the OVA is properly calibrated, the background is still higher than normal for ambient conditions, the following procedure should be followed to isolate the cause of the problem.

1) Let the OVA run for a period of time (15 to 30 minutes) and see if the background level decreases as a function of time. The background could go down and stay down as a result of clearing line contamination which is removable simply by the normal flow of air through the sample line.
2) Take a reading in a known, relatively clean air environment. Normally, outside air environment is clean enough to assess by comparison whether the background reading is internal to the instrument or is present in the laboratory, office or location where the instrument is being used.
3) If the OVA includes the Gas Chromatograph Option, depress the sample inject valve so that the activated charcoal is in the line and observe whether the background reading goes down and stays steady after the elution of the air peak. The reading should always go down or stay the same but never be a higher background reading with the sample valve depressed, since the charcoal filter will take out any trace elements of organic vapors in the air heavier than a C_2. If another activated charcoal filter is available, this may be attached to the end of the probe to scrub the air so that a clean air sample would be going to the detector. The external activated charcoal can be used on any instrument, with or without chromatograph, for providing a clean air sample to assess background level.
4) If background still stays up and cannot be reduced by any of the previous steps, the safety cover (if included) and the exhaust port on the detector chamber (Preamp Assembly) on the bottom of the case should be removed and the Mixer/Burner Assembly scraped or brushed with a small wire brush. (Reference paragraph 6.2.1.3.) This will remove any small quantities of contamination that are on the Mixer/Burner Assembly which could be the source of the background vapor. After cleaning the face of the burner and tube, replace the exhaust port and safety cover (if included) and reignite the OVA. If contamination on the burner face was the cause, the problem should be immediately resolved and the ambient background will drop to an acceptable level.
5) If the background is still present, place your finger over the inlet of the probe so as to reduce the flow of air to the detector chamber. Reduced flow rate may be observed either on the sample flow gauge or can normally be observed by the sound of the pump motor.
6) If the background drops immediately in response to the reduced flow of air to the chamber, this is an indication that the contamination is in the air sample line. Therefore, the various parts of the sample flow line such as pickup probes, umbilical cord to the instrument, etc., should be investigated by the process of elimination to see if the contamination can be isolated.
7) Serious contamination in the air sample line is very uncommon. However, if very large doses of very heavy compounds are sampled, there is a possibility of a residual contamination which would eventually clear itself out but may take a considerable period of time. A typical cause for the high background from the sample line is a

contaminated Mixer/Burner Assembly. See paragraph (4) above for cleaning procedure. If heavy contamination of the Mixer/Burner is still indicated by a high background, replace the Mixer/Burner Assembly. In several OVA models, this will require removal of the Preamp Assembly. The old Mixer/Burner Assembly should be either discarded or returned to the factory for cleaning and rebuilding.

8) In the event there is contamination in the pump or other internal parts of the sample flow lines which cannot be removed, the sample flow components would have to be disassembled and cleaned. This is normally a factory type operation. However, the components such as the pump can be replaced in the field along with any contaminated tubing in the sample lines.

9) High background readings on OVA's which include the Gas Chromatograph Option can be caused by other sources of contamination. If the charcoal in the charcoal filter mounted on the panel of the instrument is contaminated or saturated, contaminated air would be supplied to the detector and raise the ambient level background. To check for this, the charcoal filter cartridge can be removed from the panel and either a bypass tube put between the two connectors or the charcoal can be removed from the charcoal cartridge and the cartridge refilled with clean activated charcoal. This would determine if the charcoal was the source of the background reading. It is possible that an apparent high background reading could be due to contamination in the column that is on the instrument. This background could be caused by compounds that are slowly eluting from a column which has become contaminated. The easiest way to check for column contamination is to replace the column with a known clean column or a short empty piece of column tubing and see if the high background reading drops.

10) If all the above steps do not correct the high background problem, the cause will normally be contamination in the hydrogen fuel system.

Contamination in the hydrogen fuel system is usually e direct result of contamination in the hydrogen gas ed or contamination introduced during the filling eration. Filling hose contamination can be caused by ring the hose in a contaminated area.

o remove contamination from the hydrogen fuel stem, it should be purged with hydrogen. Effective ging of the hydrogen system is accomplished by sconnecting the capillary tube fitting which attaches to the manifold block which has the low pressure uge (H2 Supply Pressure Gauge and H2 Supply ve). This disconnects the capillary tubing from the drogen line so that hydrogen may be purged at a asonable rate from the tank assembly through the gulators, gauges and valves. After disconnecting the pillary, the hydrogen tank can be filled in the normal manner. The tank valve and H2 supply valve can then be opened which will bleed the hydrogen from the tank through the H2 fuel system purging out the contamination which is in vapor form. There is the possibility that contamination has been introduced into the hydrogen fuel system which is not readily purged out by the hydrogen gas but this is unlikely. After purging with clean hydrogen, approximately two or three times, the capillary tube should be reconnected and the background again checked. Five or ten minutes should be allowed before assessing the background reading, since contaminated hydrogen may still have been trapped in the capillary tube.

If another tank assembly in a clean instrument is available, the fuel system from the clean instrument can be connected to the contaminated instrument to absolutely verify that it is or is not in the hydrogen fuel supply system. The interconnection should be made to the capillary tube of the contaminated instrument.

6.2.6 FUSE REPLACEMENT

This paragraph applies only to the standard (non-certified) OVA's. There are two (2) overload fuses incorporated in the Battery Pack Assembly, one is a 3AG-1 AMP Slo-Blo in the power line to the pump and igniter and the other a 3AG-1/4 AMP in the power line to the electronics. Both fuses follow the current limiting resistors which provide primary short circuit protection. However, in the event of an excessive overload, the fuses will open and prevent overheating of the current limiting resistors. It should be pointed out that the 1 AMP Slo-Blo fuse will blow in approximately 8 to 12 seconds if the igniter switch is kept depressed. Normal ignition should take place in not more than 6 seconds. Therefore, do not depress igniter button for more than 6 seconds. If ignition does not occur, wait 1 to 2 minutes and try again. If the required 1 AMP Slo-Blo fuse cannot be readily obtained, replace temporarily with a 3 AMP-3 AG standard fuse.

6.3 TROUBLE SHOOTING

Table 6-1 presents a summary of recommended field trouble shooting procedures. If necessary, the instrument can be easily removed from the case by unlocking the four (4) 1/4 turn fasteners on the panel face and removing the refill cap and exhaust port. The battery pack is removed by taking out the four (4) screws on the panel and disconnecting the power connector at the battery pack.

6.4 FACTORY MAINTENANCE

To ensure continuous trouble-free operation, Century recommends a periodic factory maintenance, overhaul and recalibration. The recommended schedule is every six (6) to nine (9) months. This maintenance program includes replacement of plastic seals and parts as required, pump overhaul, motor check, new batteries, sample line cleaning, H2 leak check, recalibration, replacement of plastic hose as required, and detailed examination of the unit for any other required maintenance and repair.

he recommended procedure for maintenance and ›ir beyond the scope of this manual is to send the plete instrument or subassembly to the Century ›ry for repairs. The assemblies will be handled ex- ›itiously for rapid turn-around.

FIELD MAINTENANCE

though not recommended, where field intenance beyond that described herein is con- ored essential, the assembly drawings, parts lists schematics in Appendix "A" will be of assistance.

RECOMMENDED SPARES

entury does not recommend that spares be main- ›d for its instruments. However, if the instrument is › used in a remote area or spares are desired for ›r reasons, the following list should be used as a ›e

RECOMMENDED SPARES

			Recommended Quantity					
			Standard			Approved		
tem	Description	Part No.	88	98	118	108	128	138
	Igniter	510027-1	2	2	2			
	Igniter	510461-1				2	2	2
	Pump Valve	510067-3 (10/pkg.)	1	1	1	1	1	1
	Pump Diaphragm (Buna-N)	510091-1	1					1
	Pump Diaphragm (Teflon)	510063-1		1	1	1	1	
	Cup, Filter (3/8 OD, SS)	510318-1 (5/pkg.)	1	1	1	1	1	1
	Mixer/Burner Assy	510557-2	1					
	Mixer/Burner Assy	510557-1		1	1			
	Mixer/Burner Assy	510513-1				1	1	1
	Wafer, Teflon, H_2 Valve	510160-1 (10/pkg.)	1	1	1	1	1	1
	Washer, Brass, H_2 Valve	510160-2 (10/pkg.)	1	1	1	1	1	1
	Exhaust Port Assy	510425-1	1	1	1			
	Exhaust Port Assy	510530-1				1	1	1
	Battery Pack Assy	510070-1	1	1	1			
	Battery Pack Assy	510542-1				1	1	1
	Sample Line Assy	510316-1		1	1	1	1	1
	Particle Filters	510114-1	1					1
	Particle Filters	510116-1		1	1	1	1	

›E: Unit quantity is each unless otherwise noted.

TABLE 6-1

TROUBLE	TROUBLE SHOOTING PROCEDURE	REMEDY
1) Low sample flow rate on flow indicator Nominally 2 units on flow gauge. (See also 6 below and refer to paragraph 6 2.4)	a) Check primary filter in sidepack and particle filters in the pickup assembly.	Replace or clean filter if clogged (See paragraph 6 2 1)
	b) Determine assembly containing restriction by process of elimination, i.e., remove probe, remove Readout Assembly, remove primary filter, etc.	Investigate the assembly containing this restriction to determine cause of blockage. Clean or replace as required.
	c) If the restriction is in the Side Pack Assembly, further isolate by disconnecting the sample flow tubing at various points, i.e., pump output, chamber input, etc. Note: The inherent restrictions due to length of sample line, flame arrestors, etc., must be taken into account when trouble shooting.	If in the detector chamber, remove and clean or replace porous metal flame arrestors. If pump is found to be the problem, remove and clean or replace
2) H2 flame will not light. (See also 6 below)	a) Check sample flow rate (see 1 above).	If sample flow rate is low, follow procedure 1 above
	b) Check igniter by removing the chamber exhaust port and observing the glow when the IGNITE Button is depressed	If igniter does not light up, replace the plug. If igniter still does not light check the battery and wiring
	c) Check for rated H2 Supply Pressure. (Listed on calibration plate on pump bracket.)	If low remove battery pack and adjust to proper level by turning the allen wrench adjustment on the low pressure regulator cap.
	d) Check H2 flow rate by observing the PSI decrease in pressure on the H2 Tank Pressure gauge. The flow rate should be about 130 PSI decrease in pressure per hour. (Approximately 12 cc/min. at detector.) On instruments with GC Option, disconnect column and measure H2 flow rate with a bubble meter.	The normal cause for H2 flow restriction would be a blocked or partially blocked capillary tube. If flow rate is marginally low, attempt to compensate by increasing the H2 Supply Pressure by one-half or one PSI. If flow rate cannot be compensated for, replace capillary tubing
	e) Check all H2 plumbing joints for leaks using soap bubble solution. Also, shut off all valves and note pressure decay on H2 tank gauge. It should be less than 350 PSIG per hour.	Repair leaking joint
	f) Check to see if H2 supply system is frozen up by taking unit into a warm area.	If there is moisture in the H2 supply system and the unit must be operated in subfreezing temperatures, purge the H2 system with dry N2 and ensure the H2 gas used is dry
	Check battery level by connecting to charger	If in dead zone, battery may not have enough power to light flame (used with clean battery, [illegible])

	g) Remove exhaust port and check for contamination (See Figure 6 2)	If the chamber is dirty, clean with ethyl alcohol and dry by running pump for approximately 15 minutes If H2 fuel jet is misaligned, ensure the porous metal flame arrestor is properly sealed
	h) Check spacing between collecting electrode and burner tip. Spacing should be 0 1 to 0 15 inches	Adjust by screwing Mixer/Burner Assembly in or out This spacing problem should only occur after reassembling a Mixer/Burner Assembly to a Preamp Assembly
3) H2 flame lights but will not stay lighted	a) Follow procedures 2 (a), (c), (d), (e), (g) and (h) above Also refer to 5 below.	
4) Flame-out alarm will not go on when H2 flame is out	a) Check instrument calibration setting and GAS SELECT control setting Refer to paragraphs 2 3 1 2 and 2 3 2	Readjust as required to proper setting Note that on linear OVA's the flame-out alarm is actuated when the meter reading goes below zero On logarithmic OVA's, the alarm is actuated when the signal level goes below 1 ppm methane or equivalent
	b) Remove exhaust port and check for leakage current path in chamber (probably moisture or dirt in chamber)	Clean contamination and/or moisture from the chamber using a swab and alcohol, dry chamber by running pump for approximately 15 minutes
	c) If above procedures do not resolve the problem, the probable cause is a malfunction in the preamp or power board assemblies	Return preamp chamber or power board assembly to the factory for repair.
	d) Check volume control knob is turned up.	Adjust for desired volume
5) False flame-out alarm (Applies to linear OVA's)	a) Flame-out alarm is actuated on linear instruments when signal goes below electronic zero (eventhough flame is still on). This can be due to inaccurate initial setting, drift or a decrease in ambient concentration. Verify if this is the problem by zeroing meter with flame out and reigniting (See paragraph 2.3.2)	When using the X1 range, adjust meter to 1 ppm rather than zero See paragraph 2 3.2 Be sure instrument has been zeroed to "lowest expected ambient background level"
6) Slow response time, i.e., time to obtain response after sample is applied to input (Refer to paragraph 6 2 4)	a) Check to ensure that probe is firmly sealed on the rubber seal in the readout assembly	Reseat by holding the probe firmly against the rubber seal and then lock in position with the knurled locking nut
	b) Check sample flow rate per procedure 1 above	See 1 above

7) Slow recovery time, i.e., too long a time for the reading to get back to ambient after exposure to a high concentration of organic vapor.	a) This problem is normally caused by contamination in the sample input line, requiring pumping for a long period to get the system clean of vapors again. Charcoal in the lines would be the worst type of contamination. Isolate through the process of elimination (See 1 (b)).	Clean or [illegible] as required
	b) Check flame chamber for contamination.	Clean as required.
8) Ambient background reading in clean environment is too high. (Refer to paragraph 6 2 5)	a) An ambient background reading can be caused by hydrocarbons in the H2 fuel supply system. Place finger over sample probe tube restricting sample flow and if meter indication does not go down significantly the contamination is probably in the H2 fuel.	Use a higher grade of hydrocarbon free hydrogen. Check for contaminated fittings on filling hose assembly.
	b) An ambient background reading can be caused by a residue of sample, building up on the face of the sample inlet filter. If the test in 8 (a) above produces a large drop in reading, this is usually the cause.	Remove the exhaust port (it is not necessary to remove instrument from case), use small wire brush from the tool kit or a knife blade and lightly scrub surface of sample inlet filter.
	c) An ambient background reading can also be caused by hydrocarbon contamination in the sample input system. The most likely cause would be a contaminant absorbed or condensed in the sample line. Note: It should be emphasized that running the instrument tends to keep down the buildup of background vapors. Therefore, run the unit whenever possible and store it with the carrying case open in clean air.	Clean and/or replace the sample input lines. Normally the lines will clear up with sufficient running
9) Pump will not run	a) Check 1 AMP Slo-Blo fuse on the battery pack cover. NOTE: Certified OVA's do not have fuses	Replace fuse. IMPORTANT: Note that fuse is a Slo-Blo type. If fuse continues to blow when igniter switch is closed, check igniter for short circuit. If igniter is not the problem, there is a short in the wiring or pump motor. Return OVA to factory or authorized repair facility.
10) No power to electronics but pump runs	a) Check 1/4 AMP fuse on the battery pack cover. NOTE: Certified OVA's do not have fuses	Replace fuse. If fuse continues to blow, there is a short in the electronics assembly. Return OVA to factory or authorized repair facility.
11) No power to pump or electronics	a) Place battery on charger and see if power is then available. Recharge in a non-hazardous area only	If power is available, battery pack is dead or open. Recharge battery pack. If still defective, replace battery pack. Reference paragraph 2 7

D

APPENDIX D

REQUESTED ANALYSIS METHODS

TABLE D-1

(All Units are Micrograms/Liter)

PARAMETER	CAS #	METHOD DETECTION LIMIT IN REAGENT WATER
Benzene	71-43-2	1.5
Bromodichloromethane	75-27-4	1.5
Bromoform	75-25-2	1.5
Bromomethane	74-83-9	10
Carbon Tetrachloride	56-23-5	1.5
Chlorobenzene	108-90-7	1.5
Chloroethane	75-00-3	1.5
2-Chloroethyl Vinyl Ether	110-75-8	1.5
Chloroform	67-66-3	1.5
Chloromethane	74-87-3	10
Dibromochloromethane	124-48-1	1.5
1,1-Dichloroethane	75-34-3	1.5
1,2-Dichloroethane	107-06-2	1.5
1,1-Dichloroethene	75-35-4	1.5
trans,1,2-Dichloroethene	156-60-5	1.5
1,2-Dichloropropane	78-87-5	1.5
cis-1,3-Dichloroproprepene	10061-01-5	2
trans-1,3-Dichloropropene	10061-02-6	1
Ethyl Benzene	100-41-4	1.5
Methylene Chloride (*)	75-09-2	1
1,1,2,2-Tetrachloroethane	79-34-5	1.5
Tetrachloroethene	127-18-4	1.5
Toluene (*)	108-88-3	1.5
1,1,1-Trichloroethane	71-55-6	1.5
1,1,2-Trichloroethane	79-00-5	1.5
Trichloroethene	79-01-6	1.5
Vinyl Chloride	75-01-4	10
Acrylein	107-02-8	100
Acetone (*)	67-64-1	10
Acrylonitrile	107-13-1	50
Carbon Disulfide	75-15-0	3
2-Butanone	78-93-3	10
Vinyl Acetate	108-05-4	10
4-Methyl-2-Pentancne	108-10-1	(3)
2-Hexanone	519-78-6	10
Styrene	100-42-5	1
m-Xylene	108-38-3	2
o-Xylene**	95-47-6	
p-Xylene**	106-42-3	2.5

*Common Laboratory Solvent - Blank Limit is 5x Method Detection Limit
**The o-Xylene and p-Xylene are reported as a total of the two

[cmj-400-54a]

U. S. Environmental Protection Agency
HWI Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703) 557-2490 or FTS-557-2490

SAS Number ____________

SPECIAL ANALYTICAL SERVICES
Regional Request

_X_ Regional Transmittal ____ Telephone Request

A. EPA Region and Site Name: Region V Sturgis Municipal Well Field

B. Regional Representative: Dennis Wesolowski

C. Telephone Number: ( ) ____________

D. Date of Request: ____________

Please provide below a description of your request for Special Analytical Services under the Uncontrolled Hazardous Waste Dumpsite Program. In order to most efficiently obta ... your request, please address the following c ... . Incomplete or erroneous information may r ... sing of your request. Please continue resp ... attach supplementary information as n

1. General description of ana ... nalysis for volatiles by GC/MS in surface ... ow sensitivity limits.

2. Definition and number of ... whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

Analysis will be performed on 8 surface water samples and 196 groundwater samples to be considered low concentration.

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, NPDES, etc.):

MDNR lead remedial investigation

4. Estimated date(s) of collection:

5. Estimated date(s) and method of shipment: delivered daily by Federal Express.

6. Approximate number of days results required after lab receipt of samples: Laboratory will report results within 15 days of receipt of samples. 7 days for analysis

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

Organic analysis IFB WA85-J664

8. Special technical instructions (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):

1. Exceptions to Organic IFB - Attachment 1
2. Required low sensitivity limits - Table 7.
3. Requirements for determining sensitivity limits: easily recognizable spectra for all compounds using 1.5 ug/l for VOA's.
4. Initial calibrations: %RSD for RFs should be <40 for each VOA before beginning analysis.
5. Continuing calibration: run daily calibration standard before running analysis. %D should be <25 for all compounds in VOAs. If some are greater than 25%, they should be reinjected. If still out, rerun 3 point curve.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.

All deliverables included in the IFB are required including instrument sensitivity determinations. The lab will notify the Region prior to diluting any sample. If Regional approval is given to dilute, all the data will be submitted; data dilution will be reported on separate OADS forms.

10. Other (use additional sheets or attach supplementary information, as needed):

Name of sampling/shipping contact: Brian Hegge

Phone: (608) 273-0440

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

I. DATA REQUIREMENTS

Parameter	Detection Limit	Precision Desired (±% or Conc.)
As listed (Table D-1)	As listed (Table D-1)	See Attachment 1

II. QUALITY CONTROL REQUIREMENTS

Audits Required	Frequency of Audits	Limits* (±% or Conc.)
Organics as in IFB	As in IFB	Attachment 1

III. *Action Required if Limits are Exceeded:

Reanalyze. Contact Chuck Elly (312) 353-9087 or Dennis Wesslowsk.

ATTACHMENT 1

VOA - Increase sample volume up to 20 ml to meet quantitation limits.

Initial Calibration: 5 ug/L, 10 ug/L, 20 ug/L for all compounds except acrolein and acrylonitrile, which should be run at 200 ug/L, 300 ug/L, 500 ug/L.

Continuing Calibration: 10 ug/L except all those compounds that have a detection limit greater than 3.0 ug/L which are to be run at 20 ug/L. Acrolein and acrylonitrile should be run at 300 ug/L.

Surrogates: As in IFB but at 10 ug/L with percent recovery 80-120%.

Matrix spike: As in IFB but at 10 ug/L with percent recovery 80-120%.

All RFs must be ≥0.05.

NOTE: The IFB limits for the RPDs for the matrix spike/matrix spike duplicate results apply for all of the organics analyses.
For corrective action when surrogates are outside the SAS required recovery limits, see the IFB for re-extraction/re-analysis requirements.
*The surrogate and matrix spike amounts listed are the concentrations in the liter of the sample.

KDF/cmj/KDF
[cmj-400-54]

Alkalinity (H_2O) 6/29/87

U.S. Environmental Agency
CLP Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved for Scheduling

__X__ Regional Transmittal   ______ Telephone Request

A. EPA Region/Client: Region V, Sturgis

B. RSCC Representative: Dennis Wesolowski

C. Telephone Number: 312/886-1971

D. Date of Request: ________

E. Site Name: Sturgis Municipal Well Field

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for alkalinity in waters (surface waters, groundwaters, drinking waters, leachates, etc.). Samples will be unfiltered. Reports are reported as mg/l $CaCO_3$.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

196 groundwater samples (low level)

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement). RCRA, WPDES, etc.):

MDNR - lead remedial investigation

[jap-750-97]
[jap-750-96]

Estimated date(s) of collection: ______

Estimated date(s) and method of shipment: Daily by overnight carrier

Number of days analysis and data required after laboratory receipt of samples:

Laboratory should report results within 30 days of receipt of samples.

Analytical protocol required (attach copy if other than a protocol currently used in this program):

1) Alkalinity EPA Method 310.1 (Titrimetric, ph 4.5) 2) Standard Methods, 16th Edition, Method 403 4c and 4d.

Samples will be stored at 4°C until analysis and validation of results.

Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.): Samples holding time should not exceed 14 days from date of collection. Use potentiometric titration to pH 4.5 for alkalinity > 20 mg/l as $CaCO_3$. For concentrations <20 mg/l, use EPA Method 310.1 (Section 6.3) or Standard Methods, Method 403 4d. Do not use titrant volumes greater than 50ml. Obtain approval of CPMS, CRL prior to use of any other method.

Use Na_2CO_3 to standardize titrant. Standardize the pH meter and the titrant each day.

Standardize the pH meter using at least two buffers which bracket the end point.

Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion: The Test procedure used will be clearly identified. Bench records tabulating the order of analysis including pH meter calibration, titrant standardization, lab blanks, samples, lab control standards, duplicates, etc., with resulting titrant volumes or readouts will be provided along with calculation worksheets. All records will be legible and sufficient to recalculate all sample concentrations and QA audit results. Report method of titrant standardization. EPA QC Reference samples, or any other reference sample or initial calibration verification, will be identified as to source, lot number, and sample number. Corresponding "true" or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

Other (use additional sheets or attach supplementary information, as needed):

Name of sampling/shipping contact: Mike Linskens

Phone: (608) 273-0440

I. DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
Alkalinity	2 mg/l for low level	± 2 mg/l for Conc. ≤ 20 mg/l $CaCO_3$
	20 mg/l for high level	± 10% for Conc. > 20 mg/l
NOTE: These are minimum requirements. Report actual detection limits used based on allowable methodologies.		

II. QC REQUIREMENTS - Do not use designated field blanks for QA audits. The QA audits below will be done for each group of low-level and high-level akalinity determinations.

Audits Required	Frequency of Audits	Limits* (% or Conc.)
lab blank	at least 1 per group of 10 or fewer samples	<10 mg/l for high-level samples tested. <2 mg/l≤ for low-level samples tested.
lab duplicate	at least 1 per group of 10 or fewer samples	± 10% or ± 2 mg/l
lab control sample 1 set of EPA QC mineral reference samples	1 per sample set	90-110% recovery.

II. ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanlyze samples.

Contact Jay Thakkar (312) 886-1972 or Chuck Elly (312) 353-9087.

I[illegible] se return this request to the Sample Management Office as soon as possible to expedite r[illegible] essing of your request for special analytical services. Should you have any questions r need any assistance, please call the Sample Management Office.

Sulfate (H^2O)

U.S. Environmental Agency
CLP Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved for Scheduling

X Regional Transmittal ______ Telephone Request

A. EPA Region/Client: Region V, Sturgis

B. RSCC Representative: Dennis Wesolowski

C. Telephone Number: 312-886-1971

D. Date of Request: ______

E. Site Name: Sturgis Municipal Well Field

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for Sulfate in waters (surface waters, groundwaters, drinking waters, leachates, etc.) Samples will be unfiltered.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

196 groundwater samples - low level

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement). RCRA, WPDES, etc.):

MDNR lead remedial investigation

[jap-750-97]
[jap-750-92]

4. Estimated date(s) of collection:

5. Estimated date(s) and method of shipment: Daily by overnight carrier

6. Number of days analysis and data required after laboratory receipt of samples:
Laboratory should report the results within 30 days upon receipt of samples.

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

1. EPA Method 375.2 (Colorimetric Methylthmol Blue) - 1983 ed.
- Note: This method requires 0.75 mg/l SO_4 in Dilution Water(See Reagent Section 6.

2. Method 426C of Standard Methods, 16th ed. (Turbidimetric)
- Note; this last method provides for measurement of sulfate using 2 standard curves 1 for sulfate concentrations between 0 and 10mg/l, and 1 between 10 and 40 mg/l sulfate.

Samples will be kept at 4°C until validation of results.

8. Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):
Sample holding time is not to exceed 28 days from date of sample collection. Sulfate standards will be prepared daily from stock solution. Samples with absorbances or turbidities greater than that in the highest standard will be diluted and rerun. For Method 426C, 1) the reanalysis solution should conta between 20 and 40 mg/l sulfate, and 2) concentrations must be corrected for background turbidity and color per Section 5d of Method 426C using pH adjusted sample aliquots. Use only the methods specified. Calibration curves must include at least 6 points (including a zero concentration standard) for Method 375.2 and Buffer A of Method 426C.

. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.
The test procedure used must be clearly identified. Results shall be reported as mg/l SO_4. Bench records tabulating the order of calibration standard lab control standards, lab blanks, samples, spikes, etc., with resulting absorbances or concentration readouts, will be provided along with copies of worksheets used to calculate results. Background absorbances used for turbidity corrections must be tabulated for each sample aliquot tested. A photocopy of the instrument readout (ie. strip charts, printer tapes, etc.) must be included. All records of analysis must be legible and sufficient to calculate all concentrations and results.
EPA QC reference samples, or any other reference sample or initial calibration verificatic will be identified as to source, lot number, and sample number. Corresponding "true" or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

10. Other (use additional sheets or attach supplementary information, as needed):

11. Name of sampling/shipping contact: Mike Linskens

Phone: (608) 273-0440

I. DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
Sulfate	3 mg/l	Method 375.2: Differences in duplicate sample results are to be < 3 mg/l for concentrations < 50 mg/l, and < 10% for concentration > 50 mg/l. Method 426 C: Differences in duplicate sample results are to be ≤ 2 mg/l for concentrations < 20 mg/l and ≤ 10% for concentrations > 20 mg/l in aliquot tested.
Note: These are minimum requirements. Report the actual detection limits used based on allowable methodology options.		

II. QC REQUIREMENTS - Do not use designated field blanks for QA audits.

Audits Required	Frequency of Audits	Limits* (% or Conc.)
Matrix Spike*	1 per group of 10 or fewer samples	85-115%
Lab Duplicate	" "	± (10% or 3 mg/l) for Method 375.2 ± (10% or 2 mg/l) for Method 426C
Lab Blank (0 mg/l SO_4)	" "	< 5 mg/l - Method 375.2 -2 to +2mg/l-Buffer B of Method 426C or
Lab Blank (10 mg/l SO_4)	" "	8 to 10mg/l - Buffer A of Method 426C
Calibration Verification Standard	1 per group of 10 samples and at end of sample set	90 - 110%
1 Set of EPA QC Mineral Reference Samples	once per sample set	85-115% for each concentration.

*Matrix spike concentrations will be greater than 30% of sample concentrations, but spiked samples shall not exceed working range of standard curve.

I . ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanalyze samples.

Contact Jay Thakkar (312) 886-1972 or Chuck Elly (312) 353-9087.

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

Chlorides (H^2O)

U.S. Environmental Agency
CLP Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved for Scheduling

__X__ Regional Transmittal   ______ Telephone Request

A. EPA Region/Client: Region V, Sturgis

B. RSCC Representative: Dennis Wesolowski

C. Telephone Number: 312-886-1971

D. Date of Request: ________

E. Site Name: Sturgis Municipal Well Field

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for Chloride in waters (surface waters, groundwaters, drinking waters, leachates, etc.) Samples will be unfiltered.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

196 groundwater samples - low level

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement). RCRA, WPDES, etc.):

MDNR lead remedial investigation

[jap-750-97]
[jap-750-91]

timated date(s) of collection:

imated date(s) and method of shipment: Daily bu overnight carrier

ber of days analysis and data required after laboratory receipt of samples:

Laboratory should report results within 30 days of receipt of samples.

ytical protocol required (attach copy if other than a protocol currently used in s program):

1. EPA Method 325.2 (Colorimetric, Automated Ferricyanide, AA II), 1983 ed.

NOTE: A Region V CRL Auto-Analyzer manifold (0-20 mg/l) is attached for modification of Method 325.2 and to correct errors in Method 325.2.

or

2. ASTM D 512C-81 (Colorimetric, Manual Ferricyanide).

mples will be kept at 4°C until analysis and validation of results.

pecial technical instruction (if outside protocol requirements, specify compound ames, CAS numbers, detection limits, etc.): Prepare all standards , reagents, blanks, etc. th ASTM Type II reagent water or equivalent, calibration standards will be prepared ily from stock solutions. Use working concentration range or standard curve between 0-20 mg/l or less. Calibration curves must contain at least 5 points (including a zero concentration standard). Dilute and reanalyze any samples with concentrations greater an highest standard. Remove any large amounts of turbidity prior to sample analysis see Section 7.1 of Method 325.2).

Use only the specified methods. No others are allowed.

alytical results required (if known, specify format for data sheets, QA/QC reports, n-of-Custody documentation, etc.). If not completed, format of results will be to program discretion.

Bench records tabulating the order of calibration standards, rification and control standards, samples, blanks, matrix spikes, etc. with resulting ak height, concentration, or absorbance read-outs will be provided with copies of worksheets used to calculate results. A photocopy of instrument readouts, i.e. stripcharts, printer tapes, etc., must be included with all results. All records of alysis and calculations must be legible and sufficient to recalculate all sample concentrations and QA Audit results.

EPA QC reference samples, or any other reference sample or initial calibration verification, will be identified as to source, lot number, and sample number. Corresponding "ue" or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

(use additional sheets or attach supplementary information, as needed):

of sampling/shipping contact: Mike Linskens

Phone: (608) 273-0440

cloride 6/25/87

DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (+% or Conc.)
chloride NOTE: These are minimum requirements. Report actual detection limit used based on allowable methodology options.	0.5 mg/l	Differences in duplicate sample results are to be < or = to 0.5 mg/l for concentrations ≤ 5 mg/l and < or = to 10% for concentrations exceeding 5 mg/l. Report chloride concentrations to the nearest 0.1 mg/l between 0 and 20 mg/l.

. QC REQUIREMENTS Do not use any designated field blanks for QA Audits.

Audits Required	Frequency of Audits	Limits* (% or Conc.)
Matrix spike*	1 per group of 10 or fewer samples	85 - 115% Recovery
Lab duplicate	" "	+ or -(10% or 0.5 mg/l)
Lab blank	" "	< 0.5 mg/l
Calibration verification standard	" "	90 - 110% Recovery
1 set of EPA QC Mineral Reference samples - 2 concentration levels.	1 per sample set	85 - 115% Recovery

* Matrix spike concentrations will be greater than 30% of sample concentration, but spiked sample shall not exceed working range of standard curve.

ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanalyze samples.

Contact Jay Thakkar (312) 886-1972 or Chuck Elly (312) 353-9087.

e eturn this request to the Sample Management Office as soon as possible to expedite s ng of your request for special analytical services. Should you have any questions and any assistance, please call the Sample Manage...

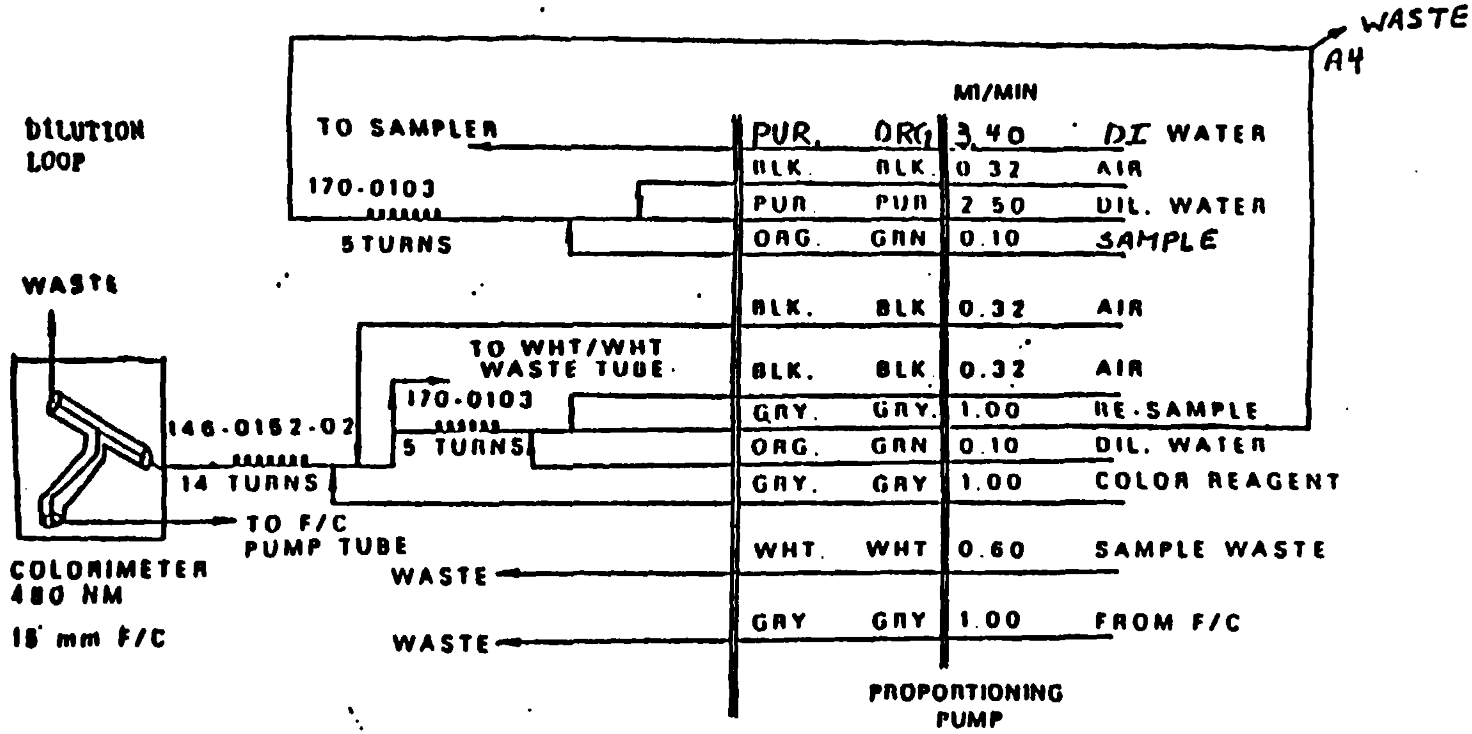


FIGURE 1
CHLORIDE MANIFOLD AA 11 0-200 mg Cl/l

To analyze samples in the range of
0 - 20 mg Cl/l, bypass the dilution loop.

TKN (H^2O)

U.S. Environmental Agency
CLP Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved for Scheduling

__X__ Regional Transmittal   ______ Telephone Request

A. EPA Region/Client: Region V, Sturgis

B. RSCC Representative: Dennis Wesolowski

C. Telephone Number: 312-886-1971

D. Date of Request: __________

E. Site Name: Sturgis Municipal Well Field

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for TKN in waters (surface waters, groundwaters, drinking waters, leachates, etc.) Samples will be unfiltered.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

196 groundwater samples - low level

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement). RCRA, WPDES, etc.):

MDNR lead remedial investigation

[jap-750-97]
[jap-750-93]

4. Estimated date(s) of collection: ______________________________

5. Estimated date(s) and method of shipment: DAily by overnight carrier

6. Number of days analysis and data required after laboratory receipt of samples:

   Laboratories shall report results within 30 days after receipt of samples

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):
   1) EPA Method 351.2 (Colorimetric, Block Digestor, AA II)
   2) EPA Method 351.3 (Calorimetric, Titrimetric, or Potentiometric) (NOTE: For Method 351.3 the micro-Kjeldahl technique is not acceptable.) Samples will be preserved in the field using H2SO4 (1ml/L) to pH<2, samples will be stored at 4°C until analysis and validation of results.

8. Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):
   For all Methods: Analyze samples within 28 days after collection. Check the sample pH (wide range pH paper). If the pH>2, contact CPMS, CRL for instructions. Use nicotinic acid for the control standard. Use an organic nitrogen compound for the matrix spike. Use only the Methods specified in item 7. Metho 351.3 requires distillation separation, prior to all final ammonia measurements.
   For Method 351.3: Use only the Colorimetric method for samples containing less than 1 mg N/l.
   For Colorimetric Methods (351.2 and 351.3): Use at least five calibration standards (including a zero concentration standard). Dilute and reanalyze samples with concentrations that exceed the highest calibration standard.
   For the Potentiometric Method (351.3): Use at least four calibration standards. Dilute and reanalyze samples with concentrations that exceed the highest calibration standard.
   For the Titrimetric Method (351.3): Standardize the titrant each day. Include records of indicator blank.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.
   Identify the test procedure and options used. Provide bench records and all records of calibration, analyses, and calculations for standards, samples blanks, any titration indicator blanks, duplicates, spikes, controls, etc. Include absorbances, peak heights, responses, concentrations, etc. for each measurement. Include digestion logs showing sample volumes and dilutions for all samples. Identify organic nitrogen compound used for matrix spikes. Records must be legible and sufficient to recalculate all concentrations and QA audit results. Provide photocopies of all instrument readouts (i.e. stripcharts, print-outs, etc). Report results as mg N/l. Identify the compound used for the matrix spike.
   EPA QC reference samples, or any other reference sample or initial calibration verification, will be identified as to source, lot number, and sample number. Corresponding "tru or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

10. Other (use additional sheets or attach supplementary information, as needed):

11. Name of sampling/shipping contact: Mike Linskens

   Phone: (608) 273-0440

DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
TKN	0.1 mg N/l	Duplicate sample results must agree within 0.1 mg/l for concentrations <1 mg/l and within 10% for concentrations > or = to 1 mg/l
NOTE: These are minimum requirements. Report the actual detection limit used based on allowable methodology options.		

QC REQUIREMENTS Do not use designated field blanks for QA audits.

Audits Required	Frequency of Audits	Limits* (% or Conc.)
Control standards (Nicotinic Acid)	one per set	70 - 110% recovery
Matrix spike*	one per group of 10 or fewer samples	85 - 115% recovery
Lab duplicate	" "	± (10% or 0.1 mg N/l)
Lab blank	" "	± 0.1 mg N/l
Calibration verification Standard	" " and at the end of the set	90 - 110%
1 set of EPA QC nutrient reference samples conc. 3 and 4.	one per set	85 - 115%

*Matrix spike concentration will be greater than 30% of the sample concentration but will not exceed the highest calibration standard. Matrix spikes will be prepared from an organic nitrogen compound.

ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanalyze samples.

Contact Chuck Elly (312) 353-9087 or Jay Thakkar (312) 886-1972.

se return this request to the Sample Management Office as soon as possible to expedite essing of your request for special analytical services. Should you have any questions eed any assistance, please call the Sample Management Office.

TOC (H^2O)

U.S. Environmental Agency
CLP Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved for Scheduling

X Regional Transmittal ______ Telephone Request

A. EPA Region/Client: Region V, Sturgis

B. RSCC Representative: Dennis Wesolowski

C. Telephone Number: 312-886-1971

D. Date of Request: ______

E. Site Name: Sturgis Municipal Well Field

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for TOC in waters (surface waters, groundwaters, drinking waters, leachates, etc.) Samples will be unfiltered.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

196 groundwater samples - low level

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement). RCRA, WPDES, etc.):

MDNR lead remedial investigation

[jap-750-97]
[jap-750-94]

Estimated date(s) of collection:

Estimated date(s) and method of shipment: Daily by overnight carrier.

Number of days analysis and data required after laboratory receipt of samples:

Laboratory should report results within 30 days of receipt of samples.

Analytical protocol required (attach copy if other than a protocol currently used in this program):

EPA Method 415.1 (combustion or oxidation).

Samples will be preserved with 1 ml/l H2SO4 to pH <2. Samples will be stored at 4°C until analysis and validation of results.

Special technical instruction (if outside protocol requirements) dilute and rerun samples with absorbances higher than the highest standard: Check sample pH with (wide range pH paper). If pH <2 contact CPMS, CRL for instructions. The holding time is not to exceed 28 days from sample collection. Homogenize samples if necessary. Qualify results where suspended solids content may affect accuracy. Instruments with syringe injection will utilize 2 injections per measurement. If the 2 injections differ by more than 10% or 2 mg/l, repeat and report the average of 4 injections. Inorganic carbon will be purged from solution or, if determined separately, subtracted from total carbon values. Obtain approval of CPMS, CRL, prior to use of any other method. The calibration curve must include at least 5 standards. (One of the standards must be zero concentration).

Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion: Test procedures and specific instrument used will be clearly identified. Bench records tabulating order of calibration standards, lab blanks, samples lab control standards, spikes, duplicates etc., with resulting output on concentration readout will be provided along with worksheets used to calculate results. Specify the organic compound used to prepare standards and spikes. A photocopy of the instrument read-out, i.e. stripcharts, printer, tapes, etc. must be included. Results are to be reported in mg/l C. Records of analysis and calculations must be legible and sufficient to re-calculate all concentrations.
EPA QC reference samples, or any other reference sample or initial calibration verification, will be identified as to source, lot number, and sample number. Corresponding "true" or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

0 Other (use additional sheets or attach supplementary information, as needed):

I. Name of sampling/shipping contact: Mike Linskens

Phone: (608) 273-0440

- DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
TOC	2 mg/l	Difference in duplicate results should not exceed ± 10% for concentrations >20 mg/l or 2 mg/l for concentrations less than 20 mg/l.
NOTE: These are minimum requirements. Report actual detection limits used based on specified methodologies.		

- QC REQUIREMENTS - Do not use designated field blanks for QA audits.

Audits Required	Frequency of Audits	Limits* (% or Conc.)
Matrix Spike*	at least 1 per group of 10 or fewer samples	85% - 115%
Lab Duplicate	at least 1 per group of 10 or fewer samples	± (10% or 2.0 mg/l)
Lab Blank	at least 1 per group of 10 or fewer samples	≤ 2.0 mg/l
Calibration verification standard	1 per group of 10 samples and end of set	90% - 110%
1 set of EPA demand QC reference samples (conc. 1 and 2)	1 per sample set	85% - 115%

*The matrix spike concentrations will be approximately 30% of sample concentrations, but spiked samples shall not exceed the working range of the standard curve.

- ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanalyze samples - Contact Jay Thakkar (312) 886-1972 or Chuck Elly (312) 353-9087.

lease return this request to the Sample Management Office as soon as possible to expedite m essing of your request for special analytical services. Should you have any questions r eed any assistance, please call the Sample Management Office.

$NO_3 + NO_2$ (H^2O)

U.S. Environmental Agency
CLP Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703)/557-2490 or FTS/557-2490

SAS Number

SPECIAL ANALYTICAL SERVICES
Client Request

Approved for Scheduling

__X__ Regional Transmittal ______ Telephone Request

A. EPA Region/Client: Region V, Sturgis

B. RSCC Representative: Dennis Weslowski

C. Telephone Number: 312-886-1971

D. Date of Request: ______

E. Site Name: Sturgis Municipal Well Field

Please provide below a description of your request for Special Analytical Services under the Contract Laboratory Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Analysis for NO_3 + NO_2 in waters (surface waters, groundwaters, drinking waters, leachates, etc.) Samples will be unfiltered.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

196 groundwater samples - low level

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement). RCRA, WPDES, etc.):

MDNR lead remedial investigation

[jap-750-97]
[jap-750-95]

Estimated date(s) of collection: ______

Estimated date(s) and method of shipment: Daily bu overnight carrier

Number of days analysis and data required after laboratory receipt of samples:
Laboratory should report results within 30 days of receipt of samples.

Analytical protocol required (attach copy if other than a protocol currently used in this program):
1) EPA Method 353.1 (colorimetric, automated hydrazine reduction).
2) EPA Method 353.2 (colorimetric, automated cadmium reduction).
3) EPA Method 353.3 (colorimetric, manual cadmium reduction).
For all methods:
Samples will be stored at 4°C until analysis and validation of results. Samples will be preserved in the field with sulfuric acid (1 ml/l) to pH<2. The analytical working range shall not exceed 0.1 to 10.0 mg/l N.

For Methods 353.2 or 353.3: If more than one reduction column is used separate calibrations, QA audits, and records are required for each column. The column used must be identified for each analytical result.

Special technical instruction (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):
Analyze the samples within 28 days after collection. Check the sample pH (wide range pH paper is acceptable). If the pH>2 contact CPMS, CRL for instructions. Use only the methods specified in item 7. Obtain approval of CPMS, CRL before using any other method.
For Methods 353.2 and 353.3: After checking the pH it is recommended that the laboratory check for residual chlorine (or oxidizing reagents) and sulfide using test strips such as starch iodide and lead acetate papers. Contact CPMS, CRL if these interferences are present; however, the laboratory must remove these interferences prior to analysis. The laboratory must also minimize interferences due to metals in order to prolong column life. (See Section 7.1.2 of method 353.3) It is suggested that the laboratory may dilute samples up to ten-fold prior to analysis (Section 7.4 of Method 353.3) provided that the final analytical working range does not exceed 0.1 to 10.0 mg/l N.
For all methods: Neutralize samples to pH 5-9 (or to phenolphthalein color end-point) prior to analysis. Dilute and reanalize the neutralized samples if the concentrations exceed that of the highest standard. Use at least five calibration standards (including a zero standard). Prepare the lab blank using 1 ml of H_2SO_4/l. Neutralize and analyze it like a sample.

Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion:
The test procedure used must be clearly identified. Bench records tabulating the order of calibration standards, lab control standards, lab blanks, samples, spikes, duplicates, etc., with resulting absorbances or concentration readouts will be provided. Worksheets used to calculate results will be included. Any sample treatment to remove interferences will be documented. The laboratory shall submit photocopies of the instrument readout (strip-charts, printer tapes, etc.) All records of analysis and calculations must be legible and sufficient to recalculate all concentrations. Results are to be reported as mg N/l.
EPA QC reference samples, or any other reference sample or initial calibration verification, will be identified as to source, lot number, and sample number. Corresponding "true" or target values and associated 95% confidence limits for analysis results will be provided for all reference samples used.

1 Other (use additional sheets or attach supplementary information, as needed):

______

1.. Name of sampling/shipping contact: Mike Linskens (608) 273-0440

I. DATA REQUIREMENTS

Parameter:	Detection Limit	Precision Desired (±% or Conc.)
Nitrate + Nitrite	0.10 mg/l as N	Duplicate results must be within 10% for concentrations >1mg/l or within 0.1 mg/l for concentrations ≤ 1mg/l Results will be reported to the nearest 0.1 mg/l for conc. less than 1.0 mg/l and to 2 significant figures for conc. exceeding 1 mg/l-N.
Note: These are minimum requirements. Report actual detection limits used based on allowable methodology options.		

II. QC REQUIREMENTS - Do not use any designated field blanks for QA audits.

Audits Required	Frequency of Audits	Limits* (% or Conc.)
Matrix Spike*	1 per group of 10 or fewer samples	85% - 115%
Lab Duplicate	1 per group of 10 or fewer samples	±(10% - or 0.1 0 mg/l)
Lab Blank (1ml/l H_2SO_4)	2 per sample set	<0.1 mg/l
Calibration verification standard	1 per group of 10 or fewer samples and at end of run	90% - 110%
Calibration blank	1 per group of 10 samples or less	< 0.1 mg/l
1 set of EPA Nutrient QC reference samples-conc. 1 and 2, or EPA F/NO_3 QC sample, WS series Conc. 1 and 2	1 per sample set	85% - 115%

*Matrix spike concentrations will be 30% or larger, of sample concentrations, but spiked samples should not exceed working concentration range of standard curve.

III. ACTION REQUIRED IF LIMITS ARE EXCEEDED:

Take corrective action and reanalyze samples. Contact Jay Thakkar (312) 886-1972) or Chuck Elly (312) 353-9087.

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

Calcium + Magnesium,
Sodium, Potassium

U. S. Environmental Protection Agency
HWI Sample Management Office
P.O. Box 818, Alexandria, Virginia 22313
PHONE: (703) 557-2490 or FTS-557-2490

SAS Number

____

SPECIAL ANALYTICAL SERVICES
Regional Request

X Regional Transmittal

____ Telephone Request

A. EPA Region and Site Name: Region V - Sturgis Municipal Well Field

B. Regional Representative: Dennis Wesolowski

C. Telephone Number: ( ) __________

D. Date of Request: __________

Please provide below a description of your request for Special Analytical Services under the Uncontrolled Hazardous Waste Dumpsite Program. In order to most efficiently obtain laboratory capability for your request, please address the following considerations, if applicable. Incomplete or erroneous information may result in delay in the processing of your request. Please continue response on additional sheets, or attach supplementary information as needed.

1. General description of analytical service requested: Calcium and magnesium, sodium and potassium of groundwater samples is to be determined.

2. Definition and number of work units involved (specify whether whole samples or fractions; whether organics or inorganics; whether aqueous or soil and sediments; and whether low, medium, or high concentration):

Analysis is to be performed on 196 groundwater samples (low level)

3. Purpose of analysis (specify whether Superfund (Remedial or Enforcement), RCRA, NPDES, etc.):

4. Estimated date(s) of collection:

5. Estimated date(s) and method of shipment: delivered daily by Federal Express.

6. Approximate number of days results required after lab receipt of samples: Laboratory should report results within 30 days after receipt of samples.

7. Analytical protocol required (attach copy if other than a protocol currently used in this program):

Calcium (dissolved) EPA Method 215.1

Magnesium (dissolved) EPA Method 242.1

Sodium (dissolved) EPA Method 273.1

Potassium (dissolved) EPA Method: 258.1

8. Special technical instructions (if outside protocol requirements, specify compound names, CAS numbers, detection limits, etc.):

Samples will be preserved with 1:1 HNO_3 to pH<2. Samples will be filtered (in-field) through a .45 micron filter prior to analysis.

9. Analytical results required (if known, specify format for data sheets, QA/QC reports, Chain-of-Custody documentation, etc.). If not completed, format of results will be left to program discretion.

Copies of all bench records for lab duplicates, matrix spikes, blanks, continuing calibration standards, calibration verification standard, and saamples with resulting concentrations will be provided with copies of any worksheets used to calculate results.

10. Other (use additional sheets or attach supplementary information, as needed):

Name of sampling/shipping contact: Brian Hegge

Phone: (608) 273-0440

Please return this request to the Sample Management Office as soon as possible to expedite processing of your request for special analytical services. Should you have any questions or need any assistance, please call the Sample Management Office.

I. DATA REQUIREMENTS

Parameter	Detection Limit	Precision Desired (±% or Conc.)
Calcium	0.01 mg/l	10% or 0.01 mg/l for conc. < 1.0
Magnesium	0.001 mg/l	10% or 0.001 mg/l for conc. < .10
Sodium	0.002 mg/l	10% or 0.01 mg/l for conc. < 1.0
Potassium	0.01 mg/l	10% or 0.01 mg/l for conc. < 1.0

II. QUALITY CONTROL REQUIREMENTS

Audits Required	Frequency of Audits	Limits* (±% or Conc.)
Lab blank	2 for sets ≤ 10 1 per 10 for sets > 10	< detection limit
Lab duplicate	2 for sets ≤ 10 1 per 10 for sets > 10	10% or detection limit
Matrix spike*	2 for sets ≤ 10 1 per 10 for sets > 10	85 - 115% recovery
Continuing calibration standard	1 per 10 samples and end of set	85 - 115% recovery
Calibration verification STD (EPA QC reference sample)	1 per set	85 - 115% recovery

* Matrix spike concentrations will be greater than 30% of sample concentration but spiked sample shall not exceed the working range of the standard curve.

III. *Action Required if Limits are Exceeded:

Reanalyze. Contact Chuck Elly (312) 353-9087.

[jam-26-7]

E

APPENDIX E

FIELD MEASUREMENT OF PERMEABILITY

FIELD MEASUREMENT OF PERMEABILITY
BAIL-DOWN TEST

INTRODUCTION

The objective is to determine hydraulic parameters (transmissivity, storativity, hydraulic conductivity) of the water-bearing strata. Single well aquifer tests are used because they may be conducted using a minimum of equipment, personnel, and time. They may also be done at many points within an aquifer and may be used to better plan a full-scale pumping test.

PROCEDURES

Each bail-down test is conducted by measuring the static water level with an electric water level indicator or cloth tape with attached sounding device, placing a pressure transducer (connected to a Hermit data logger[1]), below the water level, and removing one bailer volume from the well. The recovery of the water level back to the static level is recorded over the necessary period of time, using a logarithmic sampling mode on the data logger.

The electric water level tape and transducer are wiped, first with methanol and then with deionized water as they are placed in the wells, to prevent cross-contamination between wells. The bailer is lowered with an attached 1/8-inch stainless steel cable. The bailer and cable are decontaminated between uses by washing and rinsing with Liquinox soap and water, rinsing three times with methanol, and rinsing three times with deionized water. The bailer and cable are then allowed to air-dry on steel supports and are covered with new sheet plastic.

1 Hermit Environmental Data Logger, Model SE1000B, In-Situ, Inc., Laramie, Wyoming 82070.

DATA REDUCTION

The data accumulated during the bail-down tests are used to calculate hydraulic parameters using several published methods. Hydraulic conductivity is calculated for shallow, unconfined wells using the Bouwer and Rice method (1976). The NAVFAC method (1971) is used for comparison. Transmissivities and storativities for the deeper, confined wells are determined using the curve matching method described by Cooper, et al. (1967). For comparison, hydraulic conductivities are also calculated using the Hvorsley method (1951). All methods assume an infinite, homogenous, isotropic aquifer and an instantaneous change in head in the well.

The method described by Bouwer and Rice (1976) is based upon modifications to the Thiem equation, with the use of an analog model. A straight line is drawn through a semi-log plot of relative head versus time, and the hydraulic conductivity is calculated using the slope of that line and the geometry of the well and aquifer. The formulation assumes that draw-down of the water table around the well is negligible, that flow in the capillary fringe may be ignored, and that well losses are negligible. It is applicable to completely or partially penetrating wells in unconfined aquifers, but may be used for confined aquifers that receive water from the upper confining layer.

In the NAVFAC method (1971), a straight line is also drawn through a semi-log plot of recovery data for unconfined aquifers. The method is based on the Hvorsley method. It assumes that the well is cased below the water table, and the ratio of the screen length to the well radius (L/R) is greater than eight.

The Cooper, et al. (1967) formulation calculates the transmissivity of an aquifer by matching a plot of relative head (linear scale) versus time (logarithmic scale) to one of a set of type curves. The method assumes that the change in head after a known volume of water is injected or removed is instantaneous and that the (non-flowing) well is screened over the entire thickness of an artesian aquifer. It is directly applicable to fully penetrating screened wells in confined aquifers, but may be used to determine the transmissivity of the portion of an aquifer over which a partially penetrating well is screened, assuming no vertical flow occurs.

[1] Hermit Environmental Data Logger, Model SE1000B, In-Situ, Inc., Laramie, Wyoming 82070.

The Hvorsley method (1951) is based on a solution of the LaPlace equation and does not account for aquifer storage. A straight line is drawn through a semi-log plot of relative head versus time. The time that would be required for complete equalization of head difference if the original rate of inflow were maintained (defined as the basic time lag, T_0, and equal to the time when H-h/H-Ho = 0.37) is used to calculate the hydraulic conductivity. The value of T_0 is measured graphically, and the ratio of the piezometer length to radius is assumed to be greater than eight (L/R>8).

[jap-600-71E]

[1] Hermit Environmental Data Logger, Model SE1000B, In-Situ, Inc., Laramie, Wyoming 82070.

F

APPENDIX F

OPERATION AND MAINTENANCE OF MOUNT SOPRIS, 1000-C NATURAL GAMMA RAY LOGGING TOOL

PORTABLE BOREHOLE LOGGER

MODEL 1000-C

Operation and Maintenance Manual

Serial Number 011 to Present

September 1977

MOUNT SOPRIS INSTRUMENT COMPANY

P. O. Box 449 Industrial Park
Delta, Colorado, U.S.A. 81416
Phone (303) 874-4852 TWX 910-929-6833

ADDENDUM

Changes for Model 1000-BP

1-10.0 Change the following items to read as shown below:

10.	120 vac Charging cable	1000-BP-120
10A.	240 vac Charging cable	1000-BP-240
11.	12 vdc Charging cable	A-500K 0107

2-6.1 Change paragraph to read as follows:

Connect the proper charging cable for the voltage source available to the BATTERY CHARGE connector (Fig. 1-10). If the 12 vdc cable is used, the red lead connects to the positive (+) terminal of the source and the black lead to the negative (-). Two charging cords are provided for charging from an a.c. source, one for 120 volts and the other for 240 volts. Select the proper cable and connect the free end as follows: Black to the a.c. HOT, white to the RETURN, and green to EARTH GROUND.

NOTE: If the polarity of the 12 vdc cable is reversed, no damage will result but the batteries will not be charged.

TABLE OF CONTENTS

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION

The Model 1000-C is a complete, fully portable, lightweight (27.3 Kg-60 lbs) backpack mountable, borehole logging unit.

Using the standard probe (G375/A), it is possible to record up to three different logs in one trip in the hole: (1) Gross count, dead-time corrected gamma radiation, (2) Self Potential, and (3) Single Point Resistance. Other Nuclear Pulse counting tools available include gamma-gamma and neutron-neutron.

The recorder is a dual pen, servo-driven type, equipped with a bi-directional chart drive allowing multiple logs and re-runs without resetting the chart paper.

The power requirements for the Model 1000-C are provided by internal nickel cadmium batteries which are recharged by a built-in battery charger when connected to an A.C. or D.C. source. Battery life will provide a minimum of eight (8) hours of logging.

The hand cranked winch has two speeds: a 1:1 ratio for going down hole, and a 4:1 ratio for coming back out. The winch comes with 305 M (1000 ft.) of steel armored logging cable.

The Model 1000-C, when handled reasonably and maintained properly, will provide many years of reliable logging.

1-2.0 GENERAL SPECIFICATIONS

The Model 1000-C logger comes equipped with one combination probe, 305 M (1000') of cable, recorder-instrument assembly, shipping containers, spare parts and consumables, and all necessary cables and hardware required to log a borehole. A backpack frame with necessary fittings is optionally available.

1-2.1 Shipping Weight: 36.4 Kg. (80 lbs.)

1-2.2 Net Weight (With 305 M of cable and backpack frame): 27.3 kg. (60 lbs.)

1-2.3 Shipping Dimensions: Probe/Accessory Case = 33cm x 124.5cm x 10.2cm (13" x 49" x 4")

Winch/Recorder Case = 58.4cm x 48.3cm x 43.2cm (23" x 19" x 17")

1-2.4 Operating Temperature Range (limited by pens): -25°C (-13°F) to 55°C (131°F)

1-3.0 WINCH

1-3.1 Cable Capacity: 305 M (1000')

1-3.2 Cable Type: U. S. Steel type no. 1N10SB (or equivalent) galvanized steel armored logging cable. Single center conductor, D. C. resistance approximately 24Ω/305M. Tensil strength is 408 Kg. (900 lbs.).

1-3.3 Cable Head: Tapered cone and sleeve strain relief. Cable center conductor is water sealed with a Mecca underwater connector. Connection to probe is through center contact and outer screw threads (3/4 - 16). Outside diameter is 2.86 cm (1.125").

1-3.4 Hand Crank Gearing: Direct drive (1:1 ratio) or step down (4:1 ratio) selected with easily removable crank.

1-4.0 RECORDER INSTRUMENT ASSEMBLY

1-4.1 Depth Odometer: 5 digit bi-directional, resettable, mechanical odometer geared directly to the measuring wheel. Resolution is 0.1 M (0.1' on English models).

1-4.2 Measuring System: Hard anodized grooved aluminum wheel. The measuring wheel rotates 3 1/3 revolutions per meter (3' on English models).

1-4.3 Servo Amplifier (Recorder): Two pen, non-overlapping, servo-driven, rectilinear recorder.

1-4.4 Recorder Response Time: Time to full scale (step function in) is ~1 second.

1-4.5 Pens: Disposable felt tip cartridge available in red and black.

1-4.6 Pen lifter: Both pens operate simultaneously with front panel lever.

1-4.7 Chart Drive: Bi-directional, geared (through multi-tooth clutch) to measuring wheel. Turned on and off with front panel shift lever.

1-4.8 Chart Paper: 10 cm wide grid Z-fold paper with 1 cm x 1 cm major divisions and 0.5 cm intermediate lines. Each box contains two packets (7.6 m - 25' each) of paper. The last 61 cm (2') are marked with a red line on the right-hand margin.

1-4.9 Sensitivity: 100 mV. (F. S.)

1-5.0 GAMMA CIRCUIT

1-5.1 Ranges: 5 cps/div. (50 cps full scale) to 5 Kcps/div. (50 Kcps full scale) in 1-2-5 ratio steps.

1-5.2 Internal Calibration Source: 5.000Khz. square wave crystal oscillator with a temperature coefficient of ±0.01%/°C maximum.

1-5.3 Temperature Coefficient (total circuit): Each unit individually aligned for ±0.02%/°C maximum from -25°C to +75°C.

1-5.4 Time Constant: 2 pole Bessel function active filter. Full scale response time is ~7 seconds (step function in).

1-5.5 Deadtime Correction: Realtime analog correction adjusted to<1 micro-second as calculated by the Energy Research and Development Administration in their test pits at Grand Junction, Colorado.

1-5.6 Input Sensitivity: +380 mV ±10 mV.

1-5.7 Downhole Power: 30 vdc ±1v at 50 ma. maximum as measured at the slip rings (with combination probe connected).

1-6.0 SELF POTENTIAL

1-6.1 Ranges: 2mV./div. (20mV full scale) to 100 mV/div. (1v. full scale) in 1-2-5 ratio steps.

1-6.2 Bias Range: 0 to 500 mV + or - as selected with POLARITY switch.

1-6.3 Time Constant: 2 pole Bessel function active filter. Full scale response time is ~1 second (step function in).

1-6.4 Input Impedance: >2 megohms.

1-7.0 SINGLE POINT RESISTANCE

1-7.1 Range: 2Ω/div. (20 ohms full scale) to 100Ω/div. (1000 ohms full scale) in 1-2-5 ratio steps.

1-7.2 Displacement: 0 to 500 ohms maximum.

1-7.3 Time Constant: 2 pole Bessel function active filter. Full scale response time is ∿1 second (step function in).

1-7.4 Current Generator Output: Constant current (varies with range switch setting--20mA max.) at 25 hz to 30 hz (selected by internal switch).

1-7.5 Resistance Voltmeter Input Impedance: >500 K ohms.

1-8.0 BATTERIES & BATTERY CHARGER

1-8.1 Battery Type: General Electric type GCW3.5SB (or equivalent) Nickel Cadmium batteries (10 each).

1-8.2 Battery Rating: 1.2vdc at 3.5 Ah.

1-8.3 Battery Life: 8 hours continuous operation minimum. Varies with log(s) being run. Maximum drain is during SP-R log.

1-8.4 Battery Charger Input: 12 to 14 vdc at 1.0 A maximum, 120 vac at 0.10 A max., and 220 vac at 0.05 A maximum (A. C. input is 50 to 400 hz.).

1-8.5 Battery Charger Output: Dual, constant current outputs. 350 mA each.

1-8.6 Charging time to full charge: 12 to 14 hours.

1-9.0 PROBES

1-9.1 G375/A Standard Combination Probe

1-9.1.1 Dimensions: 1.1 m (43.5") long by 3.18 cm (1.25") maximum outside diameter including neoprene insulating sheath. The stainless steel housing is 2.86 cm (1.125") diameter.

1-9.1.2 Weight: 2.95 Kg (6.5 lbs.).

1-9.1.3 Construction: Stainless steel (type 303) housing with lead electrode for SP and R logs. O-ring sealed at all joints.

1-9.1.4 Power Requirement: 20 vdc (at cable head) minimum at 35 mA. Maximum voltage in is 30 vdc, 24 volts is nominal.

1-9.1.5 Scintillation Crystal: 38.1mm (1.50") long by 12.7mm (0.5") diameter sodium iodide, thalium activated scintillation crystal in ruggedized, sealed, aluminum mount.

1-9.1.6 Electrical Connection: Insulated center spring loaded contact and mechanical threaded attachment to cable head. Center contact is positive.

1-9.1.7 Output: 6.5v 1 microsecond wide positive pulse superimposed on the positive supply line (center conductor).

1-9.1.8 Deadtime: Constant 5.0 microseconds.

1-9.1.9 K-factor: Average K-factor at 10 cm intervals is 4.8×10^{-6} (2.5×10^{-5} at 0.5' intervals).

1-9.2 <u>G375/A-1.0 1" O.D. Combination Probe</u>

1-9.2.1 Dimensions: 1.1m (43.5") long by 2.54cm (1.0") outside diameter stainless steel housing (for very small diameter holes). The probe must be covered with a neoprene sheath or electrical tape to run the SP and R logs.

1-9.2.2 Weight 2.7 Kg (6 lbs.).

1-9.2.3 K-factor: Average K-factor at 10 cm intervals is 5.2×10^{-6} (2.6×10^{-5} at 0.5' intervals).

All other characteristics are the same as Model G375/A.

1-9.3 <u>G375/AS Stratigraphic Combination Probe</u>

1-9.3.1 Dimensions: 1.02m (40.2") long by 41.1 cm (1.62") maximum outside diameter including neoprene sheath (housing is 38.1cm (1.50") diameter.

1-9.3.2 Weight: 4.4 Kg (9.7 lbs.).

1-9.3.3 Scintillation Crystal: 76.2mm (3.0") long by 22.2 mm (0.875") diameter sodium iodide, thalium activated scintillation crystal in ruggedized, sealed aluminum mount.

All other characteristics are the same as Model G375/A.

1-10.0 CONSUMABLES AND SPARE PARTS

Item	Description	Part No.	Quantity*
1.	Chart Paper	BP-10	3 Boxes
2.	Pen Cartridge-Black (Center Nib, long)	120-430	5 Each
3.	Pen Cartridge-Black (Nib on Right, long)	130-430	5 Each
4.	Pen Cartridge-Red (Offset Right, long)	130-430	5 Each
5.	Adjustment Screwdriver	R-3324	1 Each
6.	Rubber Cable Wiper Balls	RB-1.875	2 Each
7.	Surface Electrode Assembly	B-500K 0125	1 Each
8.	Mecca Sockets	2670-6	3 Each
9.	Mecca Boot	2458-1	1 Each
10.	A. C. Charging Cable	A-500K 0124	1 Each
11.	12vdc Charging Cable	B-500K 0108	1 Each
12.	Cablehead Protector Cap	B-2000 0108	1 Each
13.	Probe Top Protector Plug	B-2000 0107	1 Each
14.	Hand Crank for Winch		1 Each
15.	O-Ring (for cable head)	2-115	1 Each
16.	Nylon Accessory Storage Bag		1 Each
17.	Recorder Protective Cover		1 Each
18.	Operation and Maintenance Manual (1000-C)		1 Each
19.	Winch-Recorder Shipping Case		1 Each
20.	Probe-Accessory Shipping Case		1 Each
21.	Standard Combination Probe	G375/A	1 Each
22.	Backpack Frame		Optional
23.	1" O.D. Combination Probe	G375A-1.0	Optional
24.	Stratigraphic Combination Probe	G375/AS	Optional
25.	Filtered Combination Probe	G375F/A	Optional

When logging in extremely remote areas, you may wish to consult Mount Sopris for a list of spare parts (including both electronic and mechanical components to allow repairs to be made in the field.

*NOTE: This quantity refers to the number of pieces shipped with each unit initially.

SECTION II

OPERATING INSTRUCTIONS

2-1.0 Incoming Inspection

The Model 1000-C should be unpacked and inspected as soon as possible. Check externally for broken knobs, bent shafts or levers, damaged connectors, etc. Also check for scratches, dents, or any gross misalignment of cases, shafts, plates, etc.

A quick incoming test may be performed as follows:

2-1.1 Chart Drive and Depth Measuring System

Shift the CHART DRIVE lever (fig. 1-13) to ON. CAUTION: do not force the lever. If necessary, rotate the CHART ADVANCE wheel (fig. 1-22) slightly while pushing the CHART DRIVE lever to ON. Reset the DEPTH odometer (fig. 1-12) to zero with the RESET wheel (fig. 1-11) Note the position of one of the pens on the chart, and rotate the MEASURING WHEEL (fig. 1-23) counterclockwise exactly 10 revolutions. The chart will move 3 cm and the DEPTH odometer will read 9997.0 meters (9991.0' on English models). Rotating the MEASURING WHEEL clockwise exactly 10 revolutions brings the chart and DEPTH odometer back to zero.

2-1.2 Recorder-Instrument Circuitry

Connect one of the combination probes to the cable head as shown in figure 4. Connect the surface electrode to the front panel connector (fig. 1-10) and short this electrode to the electrode on the probe (fig. 4). Turn the CPS/DIV. switch (fig. 1-1) to CAL, gamma DISPLACEMENT switch (fig. 1-3) to zero, and the LOG SELECTOR (fig. 1-9) to γ. The right-hand pen will go completely off scale to the right, and the left pen will slowly go to full scale ($\sim$7 seconds). Depress the left ZERO button (fig. 1-16) and see that the left ZERO control (fig. 1-15) adjusts the pen to the left and right of zero (left-hand margin). Set the left pen to zero. Turn the CPS/Div. switch to 10 (100 cps full scale). The recorder will indicate the level of background radiation. Turn the LOG SELECTOR to POWER OFF and set the following controls as indicated: POLARITY switch (fig. 1-5) to "+", BIAS control (fig. 1-6) to zero, MV/DIV. switch (fig. 1-4) to 10, Ω/DIV. switch (fig. 1-7) to 10, and resistance DISPLACEMENT control (fig. 1-8) to zero.

Turn the LOG SELECTOR to SP-R. The left pen (SP) will read near the left margin, and the right pen (R) reads up scale about 8 cm. If the right pen goes off scale to the right, check the connection between the surface electrode and probe electrode. Depress the right ZERO button (fig. 1-19) and see that the right ZERO control (fig. 1-18) will adjust the pen both left and right of the center of the chart. The zero line for the right pen is the center of the chart. Set the right pen on "zero". Turning the BIAS control clockwise will cause the SP pen to go up scale (to the right) on "+" POLARITY and down scale on "-" POLARITY.

Turning the resistance DISPLACEMENT control clockwise causes the R pen to go down scale.

Should any of the aforementioned tests fail, check to see if the LOW BATTERY indicator (fig. 1-14) is on (LOG SELECTOR on γ or SP-R); if it is, recharge the batteries (refer to sec. 1-8). Otherwise, refer to section 3-9. It is normal for the LOW BATTERY indicator (fig. 1-14) to flash as the LOG SELECTOR is switched from POWER OFF to γ or SP-R.

2-1.3 Storage

The logger should be stored in a temperate, dry area if possible. The temperature range for storage is -40° C (-40° F) to 70° C (158° F). All protective covers should be in place and the units stored in their shipping containers. The batteries should be given a full charge (12 to 14 hrs.) prior to storage and re-charged (at least 8 hours) every six months.

2-2.0 OPERATING CONTROLS

Refer to Fig. 1	Control	Function
1.	CPS/DIV:	Gamma range switch, selects the number of counts per second per division (1cm) to be recorded on the chart. In the CAL. position, the internal calibration oscillator is connected to the input of the gamma circuitry and causes the pen to go full scale (right-hand margin).
2.	Gamma CAL.:	20 turn screwdriver adjustment to set the gamma pen on full scale with the CPS/DIV. switch in the CAL. position.
3.	Gamma DISPLACEMENT:	Displaces the gamma pen down scale (to the left). The amount of displacement is equal to the CPS/DIV. switch setting (100/div. maximum) multiplied by the gamma DISPLACEMENT switch setting i.e., if the CPS/DIV. switch is on 20 and the DISPLACEMENT switch is on 15, the pen is displaced 300 cps (1½ times full scale) to the left. CAUTION: This switch must be kept on zero when the CPS/DIV. switch is on 200 or above.
4.	MV/DIV.:	Self Potential range switch. Selects the number of millivolts per division (1cm) to be recorded. Full scale for the SP pen is assumed to be at the center of the chart.
5.	BIAS POLARITY:	Selects the polarity of the bias signal fed to the SP circuit.
6.	BIAS:	Controls the amount of bias signal fed to the SP circuit. The BIAS range is 0 to 500 mv.
7.	/DIV.:	Resistance range switch. Selects the number of ohms per division (1cm) to be recorded. Zero for the R pen is assumed to be the center of the chart; full scale is the right-hand margin.
8.	Resistance DISPLACEMENT:	Controls the number of ohms and R pen is displaced to the left. The range is 0 to 500 ohms.

Refer to Fig. 1	Control	Function
9.	LOG SELECTOR:	Controls the power to all circuitry and selects gamma or SP-R operation. This switch must be in POWER OFF to allow charging.
10.	BATTERY CHARGE-SURFACE ELECTRODE:	A connector which provides connections for all battery charging and the surface electrode.
11.	RESET:	Allows resetting DEPTH odometer to zero.
12.	DEPTH:	Displays the amount of cable which has been spooled off the winch drum from the time the odometer was reset.
13.	CHART DRIVE:	Controls multi-tooth clutch to engage or disengage chart. The chart will move at a ratio of 1 meter of borehole to 1 centimeter of chart. CAUTION: Do not force the CHART DRIVE lever to ON. If necessary, rotate the CHART ADVANCE wheel slightly (to line up a multi-tooth clutch) while pushing the lever to ON.
14.	LOW BATTERY:	Indicator will come on when batteries are low. A maximum of one hour of use remains after the indicator comes on.
15 & 18.	ZERO control:	Adjusts associated pen to zero. Zero for the left pen is the left-hand margin; zero for the right pen is the center of the chart.
16. & 19.	ZERO button:	When depressed, it shorts the input of the associated servo amplifier to ground (causing the pen to read zero).
17. & 20.	SERVO GAIN:	Adjusts the amount of gain in the feedback loop of the servo amplifier.
21.	PEN LIFTER:	Mechanically raises and lowers both pens.
22.	CHART ADVANCE:	Thumbwheel to manually move the chart. CAUTION: The CHART DRIVE must be OFF.

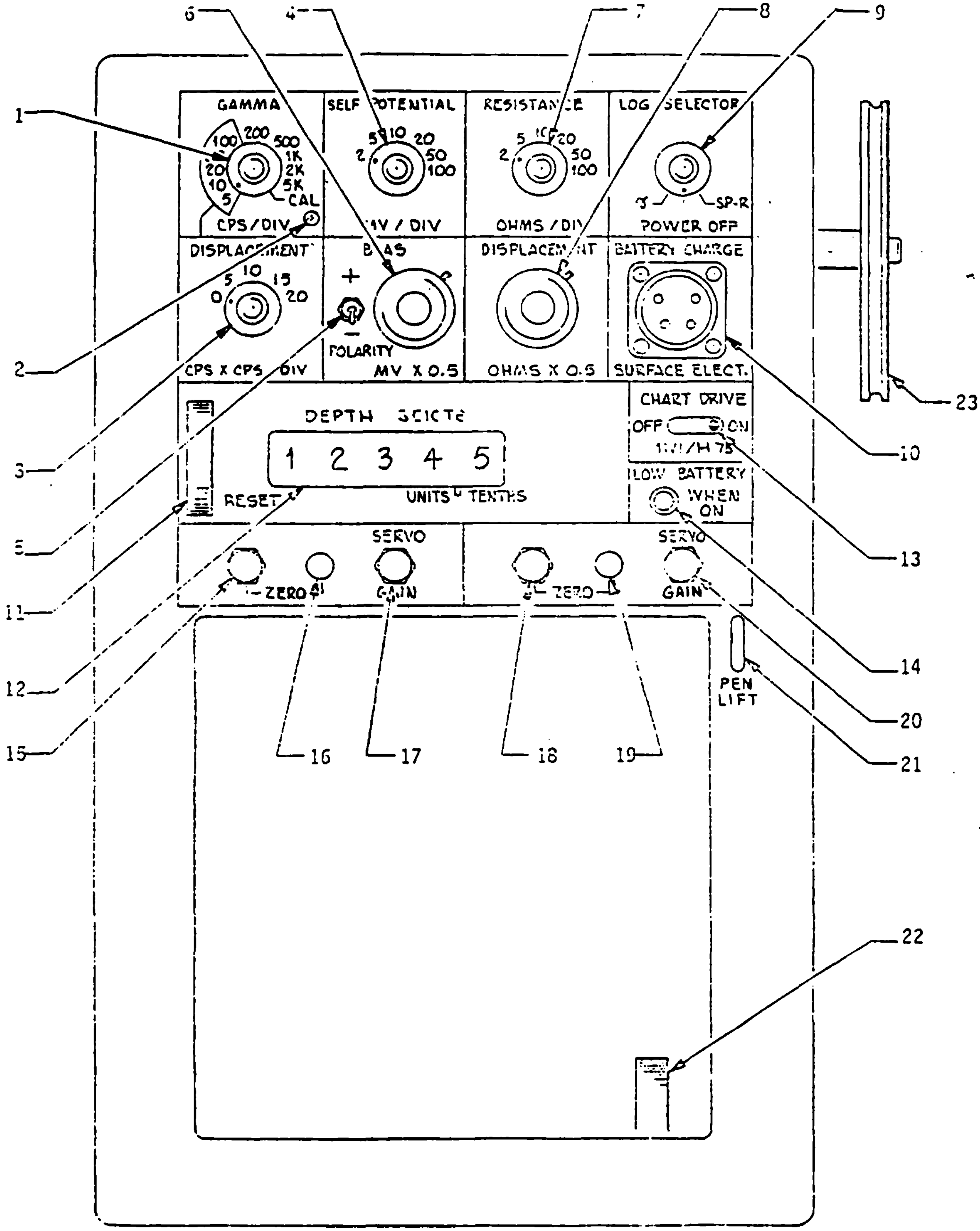


Fig. 1 Recorder Front Panel

2-3.0 Replacing Chart Paper & Pens

2-3.1 Loading Chart Paper (refer to figure 3)

It may be easier, but not necessary, to remove chart pens before loading recorder with new chart paper.

Shift the CHART DRIVE lever (refer to figure 1) to "OFF" and open the side door. Rotate chart paper thumb wheel clockwise while pushing up, from the inside, on the front end of the Teflon paper holder. The rotating sprockets will catch the paper holder and lift it up and off of the front sprocket roller. The paper holder may rub along the left side of the opening in the front panel.

The bottom end of the paper holder remains inside the recorder and around the rear sprocket roller. Do not attempt to completely remove paper holder from recorder.

Load a new packet of chart paper into recorder and thread paper up and over the front roller. Rotate thumb wheel clockwise and feed the chart paper until it engages the rear roller. Be sure the paper is flat and properly aligned on sprockets before lowering the front end of the paper holder. Maneuver paper holder down over the front roller until it catches on sprockets. The thumb wheel may then be rotated in a counter-clockwise direction. It may be necessary to hold the pens up to clear the paper holder. The paper holder will then snap into place.

Use thumb wheel to feed chart paper through recorder and into take-up magazine. Make note of which way chart paper unfolds, so that you can get paper refolding into original position.

CAUTION:

Take care not to bend the paper holder. The stretching required for the paper holder to snap on and off of roller is normal. When the paper holder is in its normal operating position, it should fit slightly loose. If the paper wrinkles or tears, or if the paper holder has a tendency to lift up during operation, the paper holder has become bent, and must be resored to its original shape.

2-3.3 Pens (Refer to Fig.1)

Turn LOG SELECTOR to POWER OFF. The pens can then be removed by grasping the front of the pen cartridge and pulling straight out. Replace with a fresh cartridge in the reverse order. When not in use, the protective caps should be kept on the pen tips to prevent the pens from drying out.

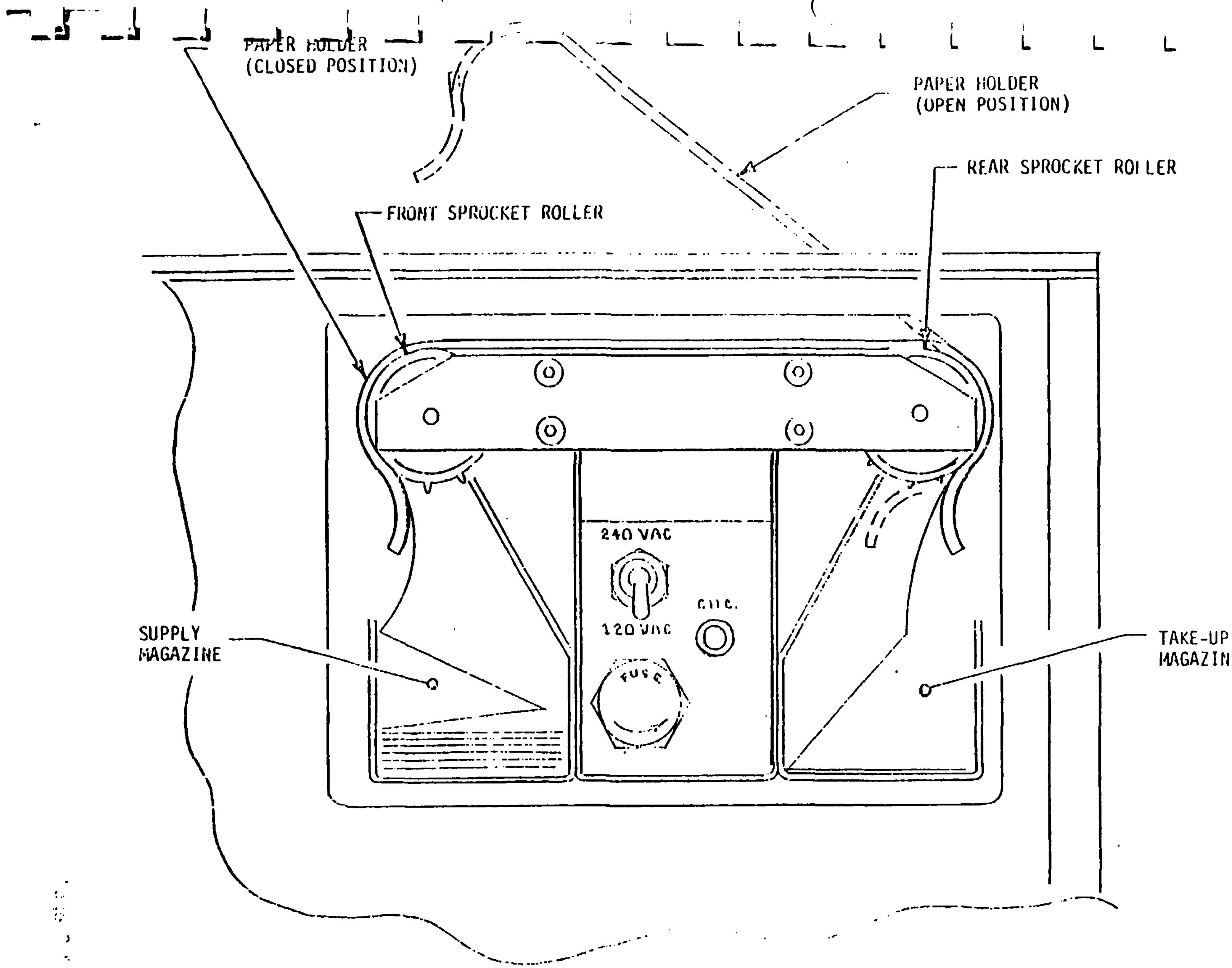


Fig. 3 CHART TRANSPORT ASSEMBLY (A)

2-4.0 Logging a Borehole

INTRODUCTION

2-4.1 The main objective for the operator of a logging unit is to produce an accurate, informative, and easy-to-read log. This means the pens make maximum use of the available chart space (full chart for Gamma and half chart each for SP and R), and do not overlap or criss-cross so much that they confuse the log. To do this requires selecting proper scales and setting bias or displacement controls properly (there is no substitute for experience). Using black pens for SP and R and a red pen for Gamma also helps keep the record straight. Since the two pens are non-overlapping, they may collide while logging SP and R. It is almost impossible to prevent this, so (if they do not separate naturally within a meter or so) the pens must be separated, using the SP BIAS control and/or R DISPLACEMENT control. Turning the R DISPLACEMENT control clockwise will cause the R pen to move to the left. Turning the SP BIAS control clockwise, with the POLARITY switch on "+", will move the SP pen to the right. With the POLARITY switch on "-" the pen will move to the left when the SP BIAS control is turned clockwise. A sample of a good log is illustrated in figure 5A and a poor log in 5B.

All three logs (Gamma, SP and R) can be run in one trip in the borehole by logging SP and R down, and Gamma on the way out. However, because of the added difficulty with this method (the hole cannot be pre-viewed on the way down to set up and SP and R controls, extra chart paper must be fed into the take-up magazine because the paper will run backwards while going down hole, etc.) it is recommended only when logging in poorly consolidated material, or when time is the ruling factor.

Prior to going to the drill site, check to make sure you have: fully charged batteries, a charging cable, spare pens (in both styles and colors), the winch crank, probe(s), extra chart paper, cable wiper balls, mud electrode, Gamma calibration screwdriver, electrical tape, and silicone grease (for O-Ring on cable head).

The following list is intended as a guideline to log a typical borehole, using the two trip method. (The probe is lowered to the bottom of the hole and Gamma is logged while coming out; the probe is then lowered a second time to log SP and R.

2-4.2 Clear the area around the borehole to give you a relatively clean, dry place to work.

2-4.3 Release the BRAKE and unspool a couple of meters of cable to give you enough slack to connect the probe and set up the tripod as shown in figure 2.

2-4.4 Place the logger on the borehole. Depending on the site, you may have to use scrap lumber, rocks, etc. to make the unit as level as possible.

2-4.5 Shift the CHART DRIVE lever to OFF. Check to see if there is enough paper in the supply magazine to log the hole.

2-4.6 Remove the protector plug from the probe and check to see that the threads and area around the contact are clean. Remove the knurled cable head protector (clean the threads and contact if dirty), apply a generous amount of silicone grease to the O-ring, and screw the probe to the cable head HAND TIGHT ONLY--do not use wrenches. The probe must be insulated with electrical tape as shown in figure 4.

2-4.7 Bury the mud plug by digging a small hole, putting the mud plug in, and filling the hole with dirt and fresh water. The mud pit will provide a good ground on freshly drilled holes. It may be necessary to use salt water to obtain a good ground in extremely arid areas. This must be noted on the log heading, as it usually reverses the polarity of the SP log.

2-4.8 Load the chart paper (refer to section II, paragraph 3) and put your log heading on it. A typical log heading might contain the unit serial number, probe serial number, probe K factor, type of logs run and their scales, hole number and location, operator's name, and the date.

2-4.9 The first log to run is Gamma, because it is usually considered most important, and depending on conditions in the borehole, one run may be all you can get. For clarity, the Gamma should be run with a red pen (SP and R in black). Remove the protective cap from the gamma pen and switch the LOG SELECTOR to γ . The right-hand pen will automatically go off scale to the right to allow full use of the chart for gamma.

2-4.10 The SERVO GAIN control (one for each channel) should be set as high as possible (clockwise) without having the recorder pens oscillate. If a recorder pen starts to oscillate, reduce the gain (counterclockwise) just to the point where the oscillation stops.

2-4.11 To check the gamma calibration, turn the CPS/DIV. switch to CAL. and alternately check for zero on the left-hand margin and full scale on the right-hand margin. Depress the left-hand ZERO button and adjust the ZERO control so the pen rests on the left-hand margin. Release the button, and the pen will come to rest near the right-hand margin. Adjust the pen for full scale with the CAL. screwdriver adjustment. Depress the ZERO button and again check for zero and then full scale to insure accurate calibration. The calibration procedure routinely should be checked before each hole.

2-4.12 Make certain the brake is set, and lower the probe into the borehole. Position the logger as necessary to center the cable in the hole. Slip the winch crank on the 1:1 ratio shaft, release the brake and crank the top of the cable head back up to ground level. Set the brake.

2-4.13 Reset the DEPTH odometer by rotating the depth RESET wheel upward, and then set in the distance from the top of the cable head, (ground level) to the reference point by manually rotating the measuring wheel. The gamma log and SP-R logs will be displaced by the distance between the center of the scintillation crystal to the center of the electrode (See Fig. 4). If this distance is considered significant, it may be compensated for by sliding the pens in or out slightly as the case may be. A good range for γ exploration is 20 cps/DIV.

2-4.14 You are now ready to lower the probe to the bottom of the hole. CAUTION: do not allow the probe to freewheel down the hole. Holding the winch crank, release the brake and crank the probe to the bottom of the hole. The bottom will be detected by the sudden loss of weight. The approximate depth can be obtained from the drilling crew.

2-4.15 When you hit bottom, take the slack out of the cable and set the brake. Move the winch crank to the 4:1 ratio shaft.

2-4.16 Adjust the chart with the CHART ADVANCE wheel so the pen will cross a major division on the chart (every 1 cm) at the same time the depth odometer indicates a whole number of meters (or at 3' intervals on English models). This makes reading the chart easier because each centimeter line will be an even depth reading i.e., every meter 273.0, 272.0, 271.0, (or 273.0, 270.0, --- 6.0, 3.0, 0.0 on English models). Shift the CHART DRIVE to ON. CAUTION: Do not force the CHART DRIVE lever. If necessary, rotate the CHART ADVANCE wheel very slightly (to line up a multi-tooth clutch) while shifting the CHART DRIVE lever to ON.

2-4.17 Check to be sure a good cable wiper ball is in place. If not, rotate the old one (or install a new ball) and cut a slice for the cable to go through.

2-4.18 You are now ready to make the first log (gamma) in the hole. Lower the pen, release the brake, and begin to crank the probe back out. A good speed for general logging is 4M/min. (15'/min.). This can be approximated by making one revolution of the crank every 2 seconds. As you come out of the hole, an attempt should be made to keep the cable as neat and level across the winch drum as possible.

2-4.19 If a gamma anomaly is encountered, the gamma pen will go off scale to the right. Continue to log until the pen comes back on scale and is reading the normal background gain. Stop cranking, raise the pen, and, while observing the pen, crank back down through the anomaly, selecting a scale which will keep the pen on scale in the upper half of the chart. Make a note of this range setting on the chart. When the pen is reading background (below the anomaly on the new scale), put the pen down and crank back up through the anomaly until the pen again returns to background. A re-run should be logged at 1 to 2 m/min (3 to 6'/min.). When the pen has returned to background, raise the pen, switch back to the original gamma range, lower the pen and continue logging the hole. A sample of a re-run is shown in figure 5c.

2-4.20 Upon reaching the top of the hole: 1. raise the pen, 2. set the brake, 3. switch the LOG SELECTOR to POWER OFF, 4. change the left pen to black (with the nib on the right) and remove the protective caps from both pens, 5. move the winch crank to the 1:1 ratio shaft, 6. switch the LOG SELECTOR to SP-R, 7. set the MV/DIV. and ohms/DIV. switch to 100, and the BIAS and DISPLACEMENT controls to zero. DO NOT shift the CHART DRIVE to OFF; the bi-directional chart drive will automatically follow the probe back downhole for the second run (SP and R).

2-4.21 Check the zero on both pens. The SP pen zero is on the left margin and the R pen zero is at the center of the chart. The scales and bias/displacement setting should be set on the trip downhole. The R pen will be off scale to the right until the water level is reached (when it comes back on scale). At this time you should start alternately lowering the OHMS/DIV. switch, to make the pen more active (larger fluctuations), and adjusting the DISPLACEMENT control to center the fluctuations on the right-hand half of the chart. The MV/DIV. switch and BIAS control are set in a similar manner; the POLARITY switch changes the polarity of the bias voltage to allow logging positive or negative SP. The SP log should cover the left-hand half of the chart and the R log the right-hand half.

2-4.22 You can now crank the probe back down the hole, setting the SP and R controls as you go. If the pens come into contact with each other, allow a few seconds for them to come back on their own, then if necessary, adjust the BIAS and/or the DISPLACEMENT controls. Turning the DISPLACEMENT control clockwise moves the R pen to the left; turning the BIAS control clockwise moves the SP pen to the right on "+" polarity and to the left on "-" polarity.

2-4.23 When you come out of the water the SP and R pens will rapidly go off scale. Raise the pens and turn the LOG SELECTOR to POWER OFF. The probe should be cranked out of the hole as fast as possible, to reduce time in the hole and the chance of getting stuck.

2-4.25 Retrieve the mud plug and wipe excess mud from it and the winch assembly. After storing the cable head and pulley assembly, tighten the cable slightly to prevent it from loosening on the drum and becoming tangled during shipping.

2-4.26 Make sure the LOG SELECTOR is in the POWER OFF position and the winch brake is on before storing or transporting the logger.

NOTE: All dimensions are in millimeters (inches)

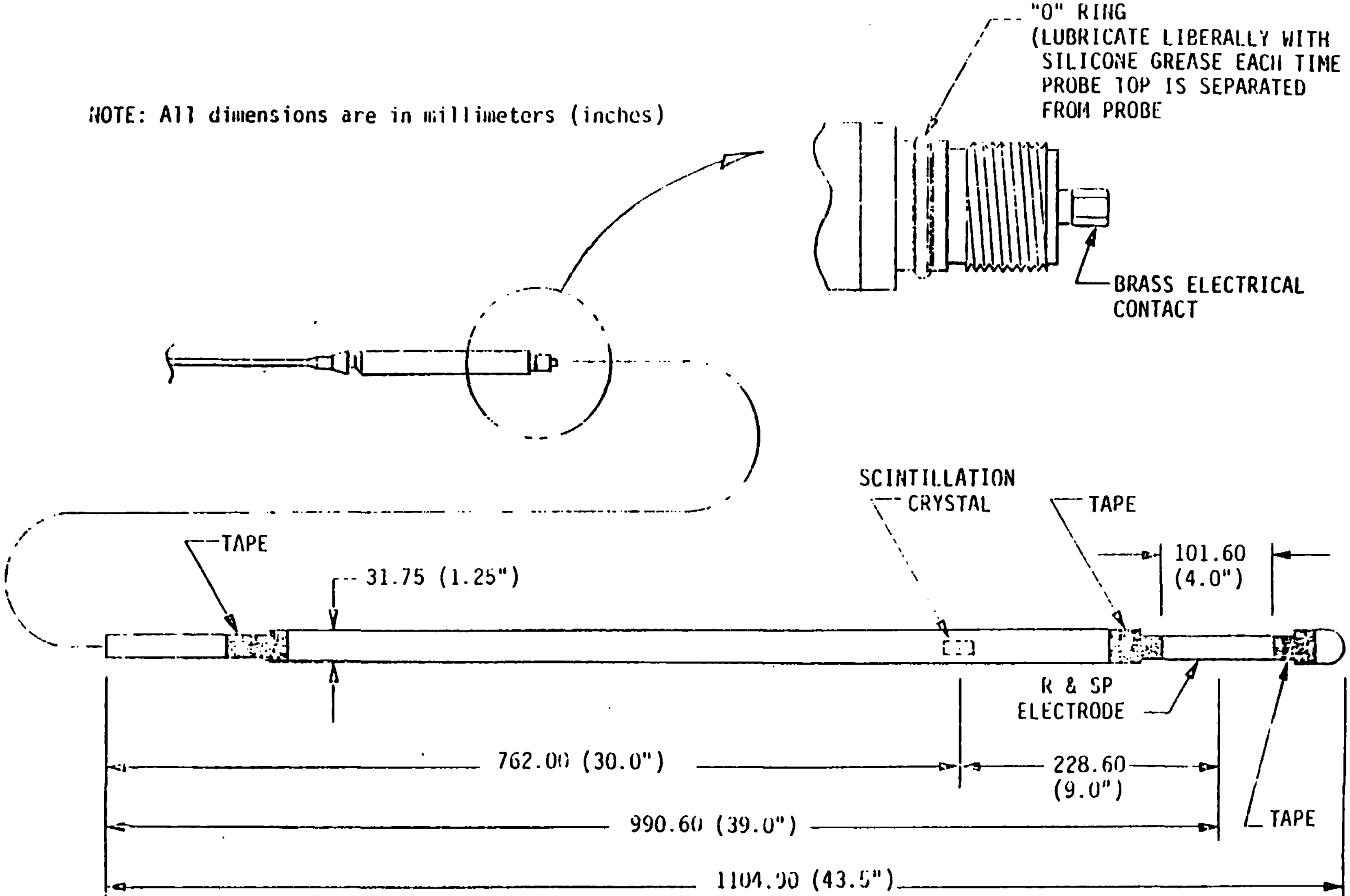
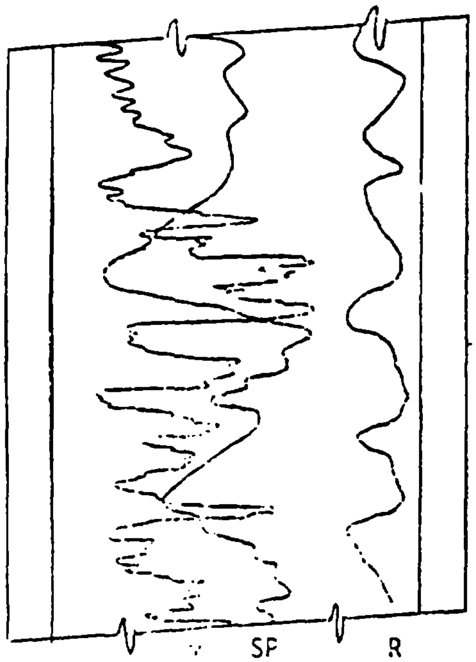
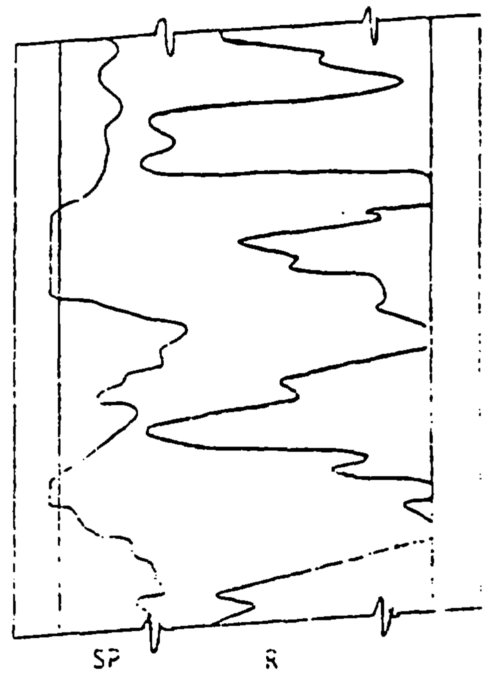


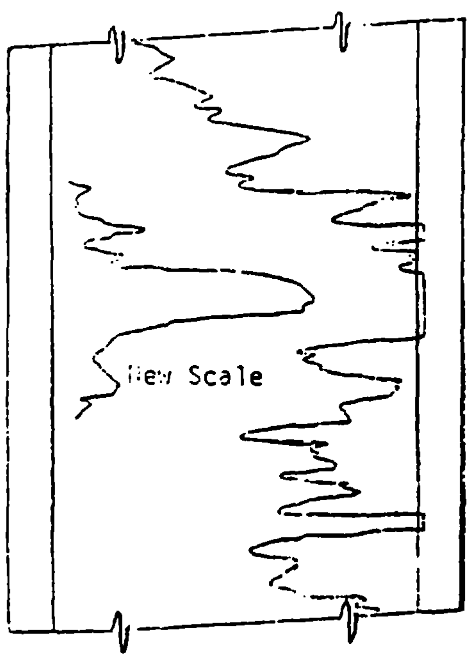
Fig. 4 PROBE DIMENSIONS



Example of a
good log
Fig. 5A



Incorrect Biasing
on the SP.
Range too high
on the R
Fig. 5 B



Re-Run
Fig. 5 C

Figure 5
Sample Logs

2-5.0 Operating Precautions

2-5.1 Keep the cable head threads and brass contact clean and the O-ring coated with silicone grease.

2-5.2 The probe top threads and area around the center connector must be kept free from dirt and grit.

2-5.3 If you become stuck in the hole DO NOT force the winch. If a moderate amount of pull from the winch will not free the probe a cable gripper and a jack or lever arm will be required.

2-5.4 When the CPS/DIV. switch is on 200 or above, the gamma DISPLACEMENT switch must be on 0 or the batteries will prematurely discharge.

2-5.5 DO NOT allow the probe to freewheel to the bottom of the hole, as damage may result to the photomultiplier tube and/or scintillation crystal.

2-5.6 In logging holes near the length of the cable, do not unspool cable completely. A minimum of 5 full wraps must be kept on the winch drum.

2-5.7 Keep the cable neat and evenly wound across the winch drum to prevent kinks and possible short circuits.

2-5.8 Do not allow the cable to kink. This causes premature wear, and could cause a short between the center conductor and the steel armor.

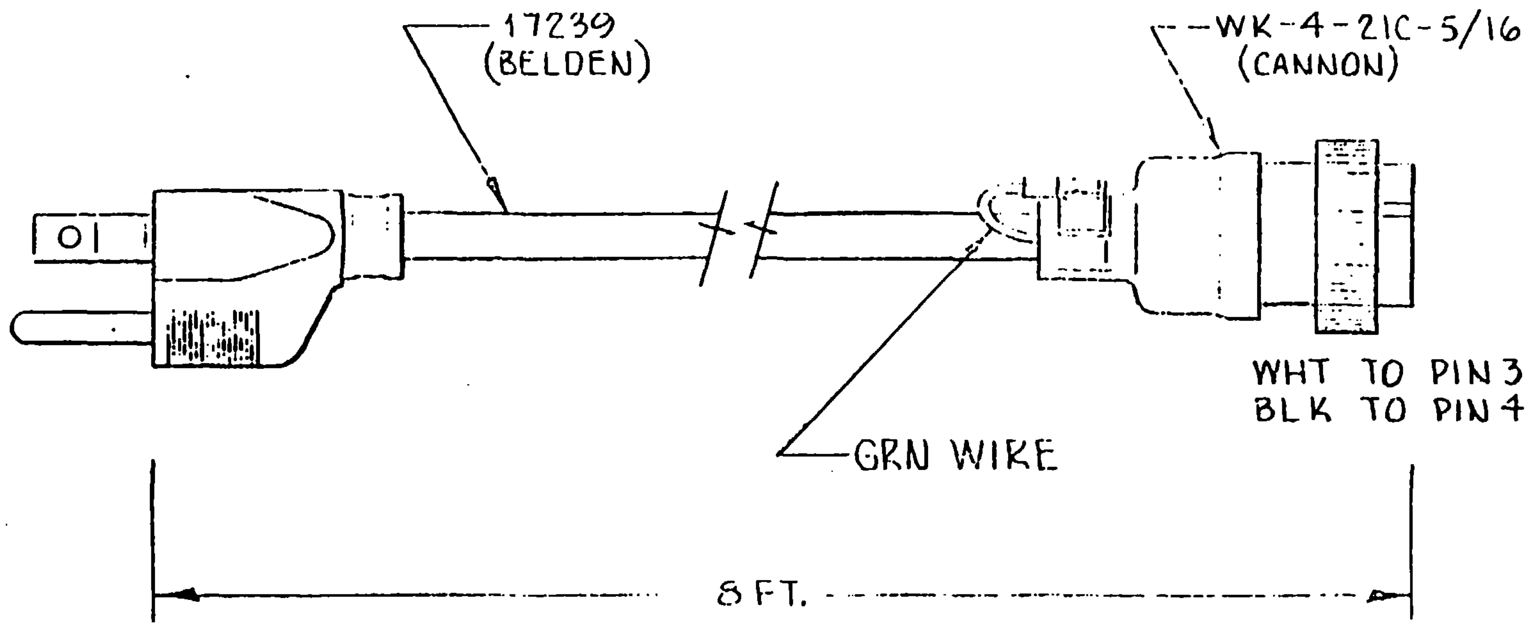
2-5.9 Handle probe with care. Avoid rapid changes in temperature and sharp blows, especially in a lateral direction.

2-5.10 LOG SELECTOR must be in POWER OFF when changing or removing probes.

2-6.0 Battery Life & Re-charging

The life of a nickel cadmium battery is largely dependent on temperature; however, there are many other factors involved (discharge rate, type of charger, etc.). The cells used in the Model 1000-C nominally give 1000 complete charge-discharge cycles. The charging system used is of the constant current type, and can be left on for an indefinite period of time with no danger of overcharging. A sensor in the charger switches automatically for 120 or 240 volt a.c. operation. It is recommended that the unit be left on charge when it is not in use, and recharged at least every six months when in storage.

2-6.1 Connect the proper charging cable, for the voltage source available, to the BATTERY CHARGE connector. If the 12 vdc cable is used, the red lead connects to the positive (+) terminal of the source, and the black lead to the negative (-). If the a.c. cord is to be used, MAKE CERTAIN the CHARGING VOLTAGE SELECTOR SWITCH (located inside the chart access door) is in the PROPER POSITION. If used on 240 v. it will be necessary to cut the cord near the a.c. plug and install an appropriate connector. Refer to figure 6 for the proper connections. Connect the cable to the power source and observe the charge light (located inside the chart access door) come on to indicate proper charging. Should the charging indicator fail to light, check the connections to the power source, make sure the power source is active, and check the fuse (a.c. operation only) located inside the chart access door. NOTE: If the polarity of the 12 vdc cable is reversed, no damage will result, but the batteries will not charge.



Pin 4----------Black----------120 v. or 240 v. (Hot)
Pin 3----------White----------120 v. or 240 v. (Return)
Conn. Shell----Green----------Earth Ground

Pin 1----Black-------Common
Pin 2----Red---------+12 to 14 v.d.c.

Fig. 6 Battery Charge Inputs

WATER AND CASING FACTOR TABLES

January 5, 1982

For Probe Model Numbers: G375/A, HLP-2375, ALP-4979

(Probes with 2SHA6/0.5-NaI(tl) PMT/Crystal assemblies and 0.065" SS wall thickness)

TABLE 1 - WATER FACTORS

Hole Diameter (Inches)	Correction Factor
2.25	1.027
4.5	1.099
6.5	1.167
8.5	1.238

TABLE 2 - CASING FACTORS (4.5" dia. hole)

Casing Wall Thickness (Inches)	Correction Factor
0.0625	1.196
0.125	1.329
0.1875	1.524
0.25	1.691
0.375	2.021

These tables supersede all previous water and casing factor tables.

G

APPENDIX G

FIELD GC METHODS

FIELD SCREENING OF VOLATILE ORGANICS

(Revised on 9/10/87)

Scope and Application: **This method covers the determination of the following organic compounds in water and soil gas.**

Compounds:

Benzene	1,1-Dichloroethane	Methylene Chloride
BromoDichloromethane	1.2-Dichloroethane	* Tetrachloroethene
Bromoform	* 1,1-Dichloroethene	* Toluene
Chloroform	* 1,2-Dichloroethene	1,1,1-Trichloroethane
Chlorodibromomethane	Ethyl benzene	* Trichloroethene

* Target Compounds

Method: **Headspace - Gas Chromatographic/Photoionization and Hall Electrolytic Conductivity Detection**

Reference: **EPA Test Methods 601 and 602 with modifications**

Detection Limits: Headspace (water): 1.0 - 50 ug/L; Soil Gas : 5 - 10 ng (injected)

Quality Control:

1. Each analytical run should begin with a target headspace standard curve consisting of 50, 10, 5 ug/L and a blank. Every eleventh analysis thereafter and the last sample analyzed should also be standards. Continuous calibration standards should be within 30% of the original standards or a new standard must be prepared and samples analyzed since the last check standard reanalyzed.

2. After the initial 3-points calibration with target headspace standards is done, the following 1-point calibration will be performed:
   2.1 Run a 1-point, 50 ug/L non-target headspace standards.
   2.2 Direct inject 5 ul of a 5 ug/ml target standard (25 ng) for a 1-point soil gas curve.
   2.3 Direct inject 5ul of a 5ug/ml non-target standards (25 ng) for a 1-point soil gas curve.

3. **A minimum of 10% duplicate samples should be analyzed. If less than 10 samples are analyzed, a duplicate sample should still be analyzed. Duplicates should be within 15%.**

4. **New stock standards should be prepared monthly in the laboratory. New secondary standards should be prepared weekly in the laboratory and brought to the field location while maintaining a temperature of approximately 4°C (iced).**

Sample Collection and Handling:

Water samples are to be collected in 40 ml VOC vials with open screw-caps and teflon faced silicone septa. They should be collected so that no headspace remains in the bottle.
Soil gas samples are to be collected in 250 ml glass bulbs. Sample should be collected in a manner to ensure the complete purging of the bulb. All samples should be protected from sunlight and transported to the field lab as soon as possible.

Reagents and Apparatus:

1. Open screw cap 40 mL vial (Pierce #13075 or equivalent). Detergent washed, distilled water rinsed and dried at 105°C before use.

2. Septum - Teflon-faced silicone (Pierce #12722 or equivalent). Detergent washed, distilled water rinsed and dried at 105°C before use.

3. 250 mL gas sampling bulbs.

4. Gas chromatograph - Varian 3400 equipped with PID and Hall detectors in series.

5. Column 1 - 8 ft x 1/8 in. stainless steel, packed with 1% SP 1000 on Carbopack B (60/80 mesh).

6. Dual-channel Integrator/Recorder.

7. Syringes -
   1 and 5 mL gas tight, fitted with shut-off valves and 22 gauge needle.
   10, 100, and 1,000 m/L gas tight.

8. 30 m/L Serum type reaction vials (hypo) with teflon lined septa and seals.

9. Balance - ±0.0001 g - (Cahn TA4200).

10. Balance - ±0.01 g - (Sartorius, 1202 MP).

11. Reagent water - organic free water or cold tap water which has been shown to be organic-free at the method detection limits.

12. 25 mL TC graduated cylinders.

13. Constant temperature water bath - 50°C.

14. Volumetric flasks - assorted.

15. Pipettes - assorted.

16. Certified gas standard solutions - 200 mg/L (Supelco).

Standard Preparation:

1. Stock Standard Solution: The stock standard solution is prepared at 5,000 mg/L methanol from pure standard materials (exceptions: 2-chloroethylvinylether is prepared at 100 g/L; 1,2-DCB, 1,3-DCB and 1,4-DCB are prepared at 25 g/L; Bromoform is prepared at 10 g/L). Correction for purities of less than 99% are made. Gas standards are purchased as a certified solution at 200 mg/L.

   1.1 Add about 20 mL of methanol to a 25 mL volumetric flask. Allow the flask to stand unstoppered until the methanol on the neck of the flask has dried.

   1.2 Tare the flask on the analytical balance.

   1.3 Using a 100 uL syringe add the reference material to the flask. Make sure the drops fall directly into the methanol without contacting the neck of the flask.

   1.4 Determine the amount of reference material added. Rinse the syringe with methanol, tare the flask, and add the next standard.

   1.5 After all the reference materials are added, fill to volume with methanol, cap, and invert to mix.

2. Secondary Standard Solution: Prepare secondary standards (target and non-target compounds) according to the following scheme:

Standard	Amount	Final Volume	Concentration
5000 ug/ml	1 ml	10 ml	500 ug/ml
500 ug/ml	1 ml	10 ml	50 ug/ml
50 ug/ml	2 ml	10 ml	10 ug/ml
10 ug/ml	5 ml	10 ml	5 ug/ml
10 ug/ml	1 ml	10 ml	1 ug/ml

Dilute to volume with methanol.

Calibration :

Water Samples (Headspace):

1.0 Working Headspace Calibration Standards: Prepare working calibration standards (target and non-target compounds) according to the following scheme:

Secondary Standard	Amount	Final Volume	Concentration
500 ug/ml	20 ul	200 ml	50 ug/l
50 ug/ml	40 ul	200 ml	10 ug/l
50 ug/ml	20 ul	200 ml	5 ug/l
10 ug/ml	20 ul	200 ml	1 ug/l

Fill a 200 ml volumetric flask with reagent water to the mark. Directly inject the secondary standards into the water with an appropriate microliter syringe.

Invert each working standard 3 times, discard the first 10 ml in the neck of the volumetric and transfer aliquots of the freshly prepared working standards to 40 ml VOC vials, (no headspace) and capped.

2.0 Calibration Procedure :

2.1 Target Headspace Standards

2.1.1 **Remove and discard 10 mL from a freshly prepared standard and place the vial now having 10 mL of headspace in a 50°C water bath insuring the water level in the bath is sufficient to equal the water level in the vial.**

2.1.2 **Allow time for equilibration of temperature (10 minutes).**

2.1.3 **Remove 5 mL of headspace for injection onto the gas chromatograph.**

2.1.4 **Construct a minimum 3-point standard curve of peak area response versus concentration for each of the compounds of interest.**

2.1.5 **A continuing calibration check is performed after each set of 10 samples and as the last sample of the day. If the response for any of the target compounds varies from the expected response by more than ±30%, a new calibration curve must be prepared.**

2.2 Non-Target Headspace Standards

Run a 1-point, 50 ug/L headspace standard of non-target compounds.

Soil Gas Samples: :

1.0 Working Soil Gas Calibration Standards : prepare working soil gas calibration standards (target and non-target compounds) according to the following scheme :

Secondary Standard	Amount	Final Volume	Concentration
500 ug/ml	1 ml	10 ml	50 ug/ml
50 ug/ml	2 ml	10 ml	10 ug/ml
10 ug/ml	5 ml	10 ml	5 ug/ml

Dilute to volume with methanol

2.0 Calibration Procedures :

2.1 **Inject 5.0 uL of each of the working standard solutions into the gas chromatograph.**

Construct a minimum 3-point standard curve of peak area response versus total nanograms injected for each of the compounds of interest.

A continuing calibration check is performed after each set of 10 samples and as the last sample of the day. If the response for any of the compounds varies from the expected response by more than ±30%, a new calibration curve must be prepared.

Sample Analysis :

1.0 **Water Samples:**

1.1 **Water samples are received in 40 mL VOC vials. Remove 10 mL of the sample from the vial.**

1.2 **The vials are placed in a 50°C water bath and allowed to equilibrate for 10 minutes.**

1.3 **Remove 5 mL of headspace for injection into the gas chromatograph.**

1.4 **If any compound of interest is outside the calibration curve and an accurate concentration is required, a smaller aliquot of headspace can be taken from a freshly prepared sample.**

2.0 **Soil Gas Samples:**

2.1 **Soil gas samples will be received in 250 mL glass bulbs. When received, they are allowed to equilibrate to the ambient air temperature.**

2.2 **Remove 5 mL of sample through the sampling septum and inject onto the gas chromatograph.**

2.3 If any compound of interest is outside the calibration curve and an accurate concentration is required, a smaller aliquot is taken from the same sample.

Chromatographic Conditions

Column:

8 ft x 1/8 inch stainless steel, packed with 1% SP-1000 on Carbopack B (60/80 mesh).

Carrier Gas

Helium - Ultra High Purity Grade (Linde)
35 mL/min

Detectors (in series)

1. Photoionization 10.2eV

   Sensitivity - Range 11 x Attenuation 8
   Temperature - 240°C

2. Hall 700A

   Mode - Halogen
   Reactor Temperature - 1000°C
   Solvent Flow - 0.8 mL/min Methanol
   Hydrogen Flow - 60 mL/min

Injector

Temperature - 220°C

Oven*

Initial - 60°C - 0 minute
Rate - 20°C/min
Final - 220°C and held for 7 minutes

* Conditions listed can be varied as needed for changing applications. Relative retention times are found on Tables 1 and 2 using these conditions.

Calculations:

1. Review the chromatograms and data reports for each analysis. Check for gross errors such as incomplete data reports because of faulty integration.

Target Headspace Calculations:

1. Review the chromatograms and data reports for each analysis. Check for gross errors such as incomplete data reports because of faulty integration.

2. Prepare external standard calibration curves for each compound using at least three data points and linear regression analysis.

3. Calculate the concentration found in the samples from the calibration curves using the following equations:

$$ug/L = A \times Df$$

where: A = Amount of compound found in the analysis in ug/L (from linear regression). Df = Dilution factor.

Other VOC Headspace Calculations:

1. Review the chromatograms and data reports for each analysis. Check for gross errors such as in complete data reports because of faulty integration.

2. Calculate the concentration of each parameter found in the samples using the following equation.

$$ug/L = \frac{R(samp)}{R(std)} \times C(std) \times DF$$

where: R(Samp) = Response of parameter in sample
R(Std) = Response of paramter in standard
C(Std) = Concentration of standard in ug/L
DF = Dilution factor

Soil Gas Bulb Calculations:

1. Review the chromatograms and data reports for each analysis. Check for gross errors such as incomplete data reports because of faulty integration.

2. Calculate the concentration of each parameter found in the samples using the following equation.

$$ng/L = \frac{R(samp) \times ng(std) \times DF \times 1000}{R(std) \times VL}$$

where: R(samp) = Response of parameter in sample
R(std) = Response of parameter in standard
ng(std) = ng of standard injected
DF = Dilution factor

VL = Volume of aliquot taken from bulb (in mL)

Data Reporting:

1. All results, standards conditions, and notes will be recorded in a bound field notebook.

2. All data generated by field G.C. will be considered as tentatively identified, with all concentrations being estimated.

3. All raw field data will be forwarded to Warzyn Engineering Inc. analytical laboratory for final review and archiving. A final summary report will be prepared with pertinent copies of the field notebook, and chromatograms included (see attached report form).

4. Analysis will be rejected for re-analyzed if:
   - duplicates are outside the 15% acceptable range.
   - continuing calibration varies greater than 30% of true value.

TABLE 1

Volatile Retention Order

Photo Ionization Detector

Parameter	Retention Time
1,1-Dichloroethene	4.24
Trans-1,2-Dichloroethene	4.98
Trichloroethene	7.23
Benzene	7.39
Tetrachloroethene	9.86
Toluene	10.81
Ethyl Benzene	13.84

Hall Detector

Parameter	Retention Time
Methylene chloride	3.26
1,1-Dichloroethene	4.29
1,1-Dichlorothane	4.77
Trans-1,2-Dichloroethene	5.04
Chloroform	5.21
1,2-Dichloroethane	5.49
1,1,1-Trichloroethane	6.12
Bromodichloromethane	6.40
Trichloroethene	7.29
Chlorodibromomethane	7.58
Bromoform	8.76
Tetrachloroethene	9.91